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Preface

We are delighted to present to you the proceedings of the 2021 International Conference on Open and Innovative Education (ICOIE), to be held in Hong Kong, China on 5–7 July 2021.

Eighteen months into the COVID-19 pandemic, educators and learners are still striving to navigate the sea of change and adapting to the new normal in learning and teaching. Maintaining high levels of student engagement in this new online learning environment remains one of the greatest challenges for educators. As such, our conference this year continues to explore the theme of ‘impacts of the pandemic on online learning’. Papers on a wide array of research topics have been accepted, most notably those concerning student engagement and learning design, pedagogical innovations, innovations in educational technology, mobile learning, learning analytics, STEAM education, and virtual reality / augmented reality in education. Due to the ongoing pandemic, ICOIE 2021 will, once again, be held as a virtual conference in which participants will present their papers through our videoconferencing system.

Openness and innovation are major trends in contemporary education that influence the entire spectrum of education institutions across the globe. Technological advancement and breakthroughs are bringing about a paradigm shift in contemporary education. Modes of learning and teaching are becoming more open and innovative in terms of time, space, curriculum contents, organization, pedagogical methods, infrastructure and requirements. Such changes are occurring in not only open universities, but also conventional tertiary institutions and schools. The use of the rapidly developing technologies of virtual reality and artificial intelligence is an example of the accelerating global trends in open and innovative education.

In view of the above, ICOIE 2021 aims to:

- provide a platform for sharing research, practices and views relevant to open and innovative education;
- facilitate networking and cross-institutional collaboration among researchers and educators in the fields of educational innovation and/or openness; and
- promote open and innovative education to enhance educational quality and achievements.

The adoption of new technologies and innovative practices has brought fundamental changes to contemporary education worldwide, and this has prompted the ICOIE to place particular emphasis on new and emerging research-based approaches to learning and teaching. We hope that, by sharing research results and good practices in meeting the needs of various types of learners, conference participants will be able to bring better or more effective techniques and technologies to their home institutions. This is also why we very much welcome a wide range of stakeholders — including teachers, professors, educators and policymakers — to join the ICOIE.

In this book, 35 full papers for ICOIE 2021 are presented according to ten sub-themes:

- Academic/Learning analytics
- Engaging students and learning design
- Impacts of the pandemic on online learning
- Innovations in curriculum development
- Innovations in educational technology
- Mobile and ubiquitous learning
- Open education
- Pedagogical innovations
- STEAM education
- Virtual reality / Augmented reality in education

We would also like to take this opportunity to share with you some exciting news about the Open University of Hong Kong. After 30 years of steady development, the OUHK has evolved from a primarily distance learning institution into a full-fledged university. To better reflect its diverse, inclusive and innovative spirit, the University is set to be renamed Hong Kong Metropolitan University on 1 September 2021. The HKMU will continue to offer distance education in addition to full-time programmes, and we look forward to continuing to organize this conference on open and innovative education each year.

Finally, we would like to extend our sincere thanks to the Educational Technology and Development Unit of the OUHK for its work on the production of this book. We are also much obliged to the dedicated staff of the Research Office for their efficiency in handling the papers. Our grateful thanks also go to the ICOIE 2021 Organizing Committee for its help throughout the preparation of this volume, and we are greatly indebted to the members of the Programme Committee for their diligent efforts in processing the papers submitted for the conference.

Editors
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July 2021

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Research on Personalized Learning Intervention Based on a Collaborative Filtering Algorithm and Knowledge Map

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Abstract
Purpose – Learning intervention refers to the efforts and attempts which are intended to enable learners to achieve certain goals. The traditional learning intervention mainly takes the teacher as the main body and often takes group intervention as the main method — although, in recent years, the growing 'one-to-one shadow education' has helped to alleviate this phenomenon. However, it is costly, poorly accessible and leads to educational inequalities. In recent years, many reliable technologies can be used in personalized education. For example, the use of a knowledge map makes knowledge points more organized, and the personalized learning recommendation method based on a collaborative filtering algorithm provides personalized intervention.
Design – This study proposes a personalized learning intervention method based on a collaborative filtering algorithm and knowledge map, which carries out teaching experiments. The subjects of the study are 152 seventh-grade students, 76 in the experimental group and 76 in the control group. The experimental group used personalized learning intervention methods, and the control group used traditional learning intervention methods. In the experimental group, the recommendation system uses a combination of a collaborative filtering algorithm and knowledge map to realize the personalized learning recommendation. After collecting the post-test scores, we analysed the experimental data.
Findings – The results showed that the personalized learning intervention method proposed in this research is more effective than the traditional learning intervention methods in improving students' learning performance. The individualized learning intervention improves the learning confidence of students with intermediate and advanced knowledge levels and reduces the learning anxiety of students with a low knowledge level.
Implications – The findings show that the method proposed in this study is effective in improving the learning effect, and also has a certain effect on the students' psychology. According to the results, this study provides a reference on implementing learning interventions for researchers, educators, and decision-managers.

Keywords: personalized learning, learning intervention, collaborative filtering algorithm, knowledge map

1. Introduction

The idea of "teaching students according to their aptitude" was put forward as early as in the Time of Confucius. According to Sukhomlinski of the former Soviet Union: "The practice of education makes us firmly believe that every student has a different personality, and the task of cultivating a new generation is to firstly develop their diversity, independence and creativity." In 2016, Berkowitz, Basham, and Hall concluded, "personalized learning means to customize appropriate learning plans for different learners according to their personal interests, strengths and needs ". With the development of technology, personalized education has changed from the traditional one-to-one and face-to-face teaching to the personalized education based on computer and tablet computer. For example, Rad et al. (2018) constructed a cloud-based artificial intelligence thinking learning platform, which aimed to provide personalized guidance for different students so that they can master the whole learning process more easily. Wang (2019) improved the personalized learning model and designed an EGL-based personalized intelligent teaching system of mathematics in primary schools, aiming at implementing personalized teaching for primary school students. Salajegheh, Jahangiri and Dolan-Evans (2016) explained that the combination of traditional learning and e-learning can promote students' understanding of knowledge and enhance their interest in learning.

With the arrival of the data era, a large amount of data provides new opportunities in many fields including the education field. Researchers provided early warning for risky students and conduct targeted personalized teaching by analyzing a large amount of learning data to conduct individual evaluation on students (Godwin-Jones, 2017). Jiang (2019) studied the application of four data mining technologies, namely clustering, classification, correlation analysis and specific grouping, in personalized teaching and proposed a set of personalized teaching system based on big data. Despite the increasing abundance of learning resources, it is still difficult to provide individual students with the learning materials they need. In order to solve this problem, many scholars have done exploration and research. In recent years, collaborative filtering algorithm has been widely applied in personalized learning recommendation system. Dan Zhang et al. improved user-based collaborative filtering algorithm and obtained good personalized recommendation effect (Zhang, 2016). John K. Tarus et al. (2018) summarized relevant researches on recommendation system of the Department of Electronics based on knowledge ontology, showing that mixed recommendation method based on knowledge can improve the effect of learning recommendation, which will also be the trend of future research.

The existing personalized education mainly focuses on learning prediction, and there are few studies on learning intervention, and most of the related studies on learning intervention system are still at the theoretical level, which lacks the support of empirical research. Traditional learning interventions are not precise enough to be individualized. Traditional collaborative filtering algorithm recommend learning resources to students by determining that students' nearest neighbors. However, students with the same academic record may have different degrees of understanding on knowledge points. It is a reliable method to classify according to their mastery degree on knowledge points (John et al., 2018). There are some existing problems on the currents such as ignoring the mastery degree of knowledge points related to learners and not digging deeply enough into the factors affecting learners, which all affect the accuracy and learning effect of personalized education. Therefore, this study proposed a new learning intervention method based on the framework of learning recommendation system proposed by Chen et al. (2018). Collaborative filtering algorithm is used to evaluate the scores of knowledge points based on the advantages of knowledge map, classify students based on their knowledge mastery, and generate knowledge mastery map to recommend topics to students accordingly, finally forming personalized push. Based on the personalized learning recommendation system constructed by Xue Tang et al. (2019), a research framework of personalized learning intervention was constructed and empirical research was conducted to provide suggestions for the personalized learning research in the future.

2. Literature review

2.1 Definition of related concepts

As the economic model has changed, the traditional education model has been unable to meet the needs of the society, so the personalized education model has emerged. Zhao (2012) mentioned in a speech that Personalized education should be used to replace standardized education in order to reform education. Personalized Education is a kind of education model. It follows the concept of personalized medicine and aims to use students' personal interests, values and preferences to improve students' interest in learning subjects. New technologies may be used for the purpose of personalized education, which is called an intervention (Bernacki＆Walkington,2018). Recent studies have found that Personalized education can increase students' interest in the situation in a short time, which is very important for promoting students' long-term interests. Personalized Learning (PL) is the U.S. Department of Education's 2016 National Education Technology Plan, which emphasizes that Personalized Learning can revolutionize technology-based Learning, and defines PL as "teaching optimized for each learner's Learning schedule and teaching method needs. Learning objectives, teaching methods and teaching content can be changed according to the needs of learners "(Walkington＆Bernacki,2018). PL is a differentiated teaching model that addresses each student's readiness, interest, and learning through content, process, and product differentiation. Personalized Learning is often seen as a guide that uses technology and device support to achieve high level Learning (Grant & Basye). Adaptive learning is an educational technology, which can make use of existing technologies to achieve differentiation and individuation of learning paths. Brusilovsky and Peylo (2003) argued Adaptive learning refers to how to use computer systems or tools to provide tailored learning materials or activities for learners to meet personalized needs. Although the concept of adaptive learning is general, it has the same purpose as personalized learning, that is, future learning should be more personalized. Adaptive learning works together with the popular big data, learning and analysis technology. These technologies are changing the world of education (Kerr, 2016). According to the above definition, Personalized Education is a big concept and represents an emerging education model. The difference between Personalized Learning and Adaptive Learning is that they meet the Personalized needs of learners in different ways.

Concept Map (CM) is a graphic tool that uses nodes to represent concepts and graphical forms to represent knowledge structures. The arcs between nodes represent the mutual relations between nodes. The connection phrases on the arcs describe the semantics of the connection (Ruiz-Primo & Shavelson). Knowledge Map is also a kind of drawing, in which the contents in shapes represent concepts or things, and the connecting lines represent relationships. Both Concept map and knowledge map are helpful for learners to organize, understand and memorize knowledge (Woo et al., 2004). In order to make better use of knowledge map to promote knowledge acquisition, many scholars try to put forward different methods to use knowledge map. The application of Knowledge Map can be divided into two aspects. On the one hand, Knowledge Map is used to represent the constituent concepts of prior experience and the cognitive structure of prior experience. On the other hand, Knowledge Map is used to represent the knowledge, ability and skills that learners should achieve. Researchers even divide the use of Knowledge Map into five categories: identifying knowledge resource map, organizing knowledge resource map, identifying knowledge structure map, and knowledge development map (Watthananon & Mingkhwan). In this study, the Knowledge Map is applied as a test of students' knowledge learning effect and represents the learnable component of students' learning activities.

2.2 Personalized Learning Intervention Research

Learning intervention is a key step to enhance and improve the learning effect, and many scholars have carried out relevant research. At present, there is no fixed definition of learning intervention at home and abroad. Cenkner believes that learning intervention is intended to enable educators to discover all behaviors of learners' knowledge, skills and attitudes (Cenkner,2006). Based on existing research and summaries of expert, this study holds that the personalized learning intervention now refers all sorts of learning instruction behavior launched for promoting the development of teaching by identifying student status with the support of technology. With regards to the personalized learning intervention research, different scholars respectively conduct attempts from the theoretical research and empirical research on learning intervention.

Theoretical research includes the construction of personalized learning model and the design of learning intervention system. For example, Chris Piech et al. (2012) designed a learning prediction model to identify students with learning difficulties, which can provide timely intervention. The development of adaptive learning system and the use of educational data mining and learning analysis technology can not only provide personalized learning programs, but also push personalized learning resources to students so as to do learning intervention. The personalized learning system set up by such as "data collection, data preprocessing, pattern discovery and application", which are used to collect and analyze student data (Chaoyang Ji et al., 2013). Karim et al. (2019) proposed a Spark and Hadoop-based learning recommendation system, with functions of data storage, resource management and data processing and analysis. They proposed a distributed course recommendation patch system, which can help students obtain more appropriate teaching resources according to their learning feedback.

The empirical research includes the exploration of the factors affecting the learning effect, the development and utilization of learning intervention tools, and the exploration of learning intervention methods. For example, Beth Dietz-Uhler et al. studied what kind of learning tools can effectively improve students' learning efficiency. Jia-hua Zhang et al. (2018) conducted long-term large-scale data collection and analysis via the Moodle platform to find the key factors affecting the learning effect, such as learning duration, social interaction, learning support services, etc. So as to establish appropriate intervention strategies for students on this basis. Nikola Tomasevic et al. (2020) solved the task of predicting students' exam results by using learning analysis based on machine learning technology to improve students' learning. Combined with the background of big data and the existing results on studies, students' personalized learning intervention process usually requires steps such as data analysis to students, intervention strategy formulation, intervention implementation and effect feedback.

2.3 Methods of Learning Intervention

According to different classification criteria, common learning interventions can be divided into two categories: traditional learning interventions and technology-supported learning interventions. The traditional learning intervention is usually manual intervention and collective intervention. Manual intervention is mainly used in traditional classroom teaching. Teachers can directly conduct intervention to learners after discovering problems, such as increasing exercises, talking with students, adjusting teaching methods and other behaviors. In the classroom, the teacher can assess students' knowledge weaknesses according to the performance of the whole students, and the behavior of explaining a certain exercise or knowledge point can also be regarded as collective intervention. In addition, Shadow Education has grown along with the expansion of formal schools. Shadow education involves supplementary learning that mimics formal schooling and extends the regular school day. Private education is a type of shadow education, which provides students with one-on-one education. It is currently popular in many countries (Marshall & Fukao,2019). However, this approach not only requires a large number of teachers, but is also very expensive to educate, may negatively affect students' normal school hours, and raises doubts about the ability of public education to provide equal learning opportunities for all (Dawson, 2009; Kiger & Prunty,2012).Technology-supported learning intervention is a rising learning intervention with the maturity and development of technical means. It refers to the intervention under the support of informal learning or mixed learning techniques. The participation of technical means can promote the realization of personalized learning (Picciano, 2014). Common researches include the application of learning analysis techniques and the construction of personalized learning systems. Burke (2007) and Adomavicius and Tuzhilin (2005) make a distinguishment between different categories of learning recommendation techniques, including collaborative filtering technique, content-based method, knowledge-based method, demography-based method and hybrid recommendation method, etc.

The current personalized recommendation methods can generally be divided into three categories: the content-based recommendation algorithm, collaborative-filtering-based recommendation algorithm and hybrid recommendation method (Adomavicius & Tuzhilin,2005). Content-based learning recommendations are similar to recommending content to users that users have liked in the past (Gwo-Jen Hwanga et al., 2010). Collaborative filtering is a method of recommending services to users based on their past preference for similar tastes (Zhe wang,2017). Hybrid recommendation method combines content-based approach and collaborative approach by adopting different ways (Baidada, Mansouri & Poirier,2018). Collaborative filtering algorithm is widely used in personalized learning recommendation research. Many scholars in recent research made some improvement on the user-based collaborative filtering algorithm, for example. Hanjo Jeong and Kyung Jin CHA (2019) proposed a collaborative filtering method based on the map, the collaborative filtering algorithm based on user of K-Nearest Neighbor (KNN) classification algorithm is one of the simplest method of data mining classification techniques, and each sample can be represented by using the closest K Neighbor. The data in the sample can be classified in this method. Ying Tang et al. (2020) used KNN classification to evaluate learners' conceptual knowledge and provided personalized feedback, which effectively improved students' learning effect.

The study found that the hybrid recommendation method based on collaborative filtering algorithm mixed with other recommendation technologies was more effective in improving the learning recommendation outcomes (Tarus et al.,2018; Wan et al.,2016). Mei-Hsiang Wang et al. (2012) constructed a knowledge map system that can promote knowledge sharing based on the advantages of knowledge map, which is technically optimized. The results show that most respondents agree with the usefulness and ease of use of the knowledge map. Yotta, an online learning system, centered on knowledge map, is built by Qinghua Zheng et al. (2010). The Yotta system is based on knowledge map and can display knowledge content from unit to concept. This system can automatically extract unit knowledge and generate a clear knowledge map, thus solving the problem of low learning efficiency caused by manually established knowledge map. Tarus, J. et al. (2018) conducted a literature review on learning recommendation technology and found that the use of e-learning recommendation system could improve the quality of suggestions, and the hybrid recommendation technology could be based on ontology.

Previous studies have focused on the improvement and application of collaborative filtering algorithms, and a single approach is often adopted in the design of personalized learning intervention systems. Existing studies have proved that hybrid recommendation technology is very useful, but few studies have used the two methods in combination. Based on this, this study proposed a new hybrid recommendation method based on the combination of knowledge map and collaborative filtering algorithm to provide students with more accurate personalized learning recommendation, and carried out relevant empirical research to explore the application effect of this method in practical teaching activities.

3. Construction of Personalized Learning Intervention Framework

This study proposes a research framework for personalized learning intervention, as shown in Figure 1. This research framework is based on the adaptive learning System Framework proposed by the Us Department of Education bulletin, which contains six parts: adaptive learning content, student learning database, prediction model, visual report, adaptive engine and intervention model (Bienkowski et al., 2012). On this basis, this study further combined the advantages of knowledge map and collaborative filtering algorithm and made an improvement and optimization. The framework of this study includes five parts: information collection, database establishment, data analysis, personalized intervention implementation and intervention effect analysis. Through three iterations of experimental intervention, SPSS was used to analyze the data of students' scores and psychological factors, analyze the outcomes of intervention, and finally present the analysis results to teachers and learners. The following is the specific content of this research framework.

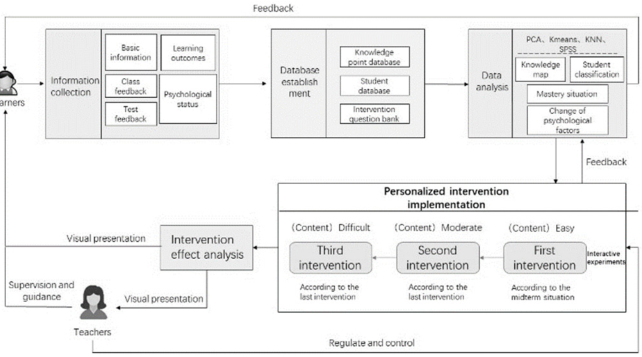

Figure 1. Personalized learning intervention Research Framework

3.1 Information Collection and Database Establishment of Learners

Before the beginning of this study, the basic information, previous learning achievements, test scores and psychological status information of students were collected and put into the student database. In this part, information is collected mainly by means of questionnaires. Learning achievements are students' previous test scores stored in the educational *administration* system of the school. In addition to the basic information, learners' emotional or motivational state is an important factor affecting the learning effect, and psychological factors will affect learners' learning state(Li, Chengchen ＆ Jinfen Xu, 2019). Therefore, these psychological factors should be taken into account when designing teaching activities（Muñoz-Restrepo，Ramirez ＆ Gaviria, 2020）.Therefore, this study not only focuses on the changes of learners' academic performance, but also focuses on the changes of students' psychological factors, including relevant data of learning motivation, learning anxiety, learning confidence, self-efficacy, learning engagement and other psychological factors. In this way, we can not only discuss the influence of personalized learning intervention on students from the change of academic performance, but also hope to make an explanation to the experimental results from the psychological change, and provide a theoretical basis for the effectiveness of the personalized learning intervention method proposed in the study. For the convenience of the data storage and more smooth data call in the later period, three databases were constructed in the second stage: knowledge point database, student database and intervention question bank. Among them, the knowledge point database refers to the knowledge content of this test unit, and each specific knowledge point is divided and stored in the bank. The student database contains the basic information of students, their previous academic grades, and psychological information and test scores. The intervention question bank is constructed according to the unit knowledge content. In a bid to improve students' ability to master and apply knowledge, the question bank is divided into three levels according to the difficulty: easy, medium and difficult. The concept content and test content are named in line with the type.

3.2 Data Processing and Analysis

Data processing and analysis is an important step in personalized learning recommendation. In order to make the content of unit knowledge clearer, knowledge map is first used to decompose unit knowledge and then generate to the unit knowledge map. The knowledge map of the first three units of mathematics in grade 7 is presented, which makes the knowledge hierarchical and easy to understand. Then the knowledge points involved in each question in the test paper is decomposed and then a table is made according to the language points. By analyzing students' scores of each question, KNN algorithm was used to classify the student's level. At last, the graph of students' knowledge mastery is generated, and then the appropriate knowledge questions are found from the database to recommend personalized learning resources for students.

In the stage of student classification, KNN algorithm is mainly applied. Since the test paper contains many questions and knowledge points, Principal Component Analysis (PCA) is adopted to reduce the dimensionality of multivariate data in analyzing the knowledge point scores of students, and Kmeans is adopted to analyze the data clustering. According to the existing clustering results, KNN was used to classify the students.

The student sample space is expressed as $X=\{S_i| \ i=1,2...,n\}$, a total of n student samples, and each student sample S_i is a p-dimensional vector, which can be expressed as $S_i=\{p_{ij}|j=1,2..., p\}$.Therefore, the p_{ij} vector represents the score of the ith student on question j.The test sample set is expressed as $T=\{t_{ij}| \ i=1,2...,m; j=1, 2,...,p\}$, which represents the j eigenvectors of the ith test data. An initial value of K is set and adjusted according to the sample until it achieves optimization. The K of the nearest user sample The K nearest the user sample is chosen and the classification of the test samples acquired, and then the t0-be-classified samples are concluded as Ω class, thus gaining the level of students. In the process of processing the unit knowledge, the concept of knowledge map is used to generate unit knowledge map. Judging what kind of intervention is offered to students is of great importance. In the main stage of judging students' mastery situation of knowledge, the form of knowledge map is adopted to show the mastery degree of students' knowledge. According to the master situation of each knowledge point, the corresponding test questions is found from the existing question bank for recommendation. This paper puts forward the score rate d of students' knowledge point, and judges the degree of students' mastery of a certain knowledge point according to the value of d. The study supposes that the score of a certain knowledge point is D, the total score of the knowledge point is S, and the mastery situation of the students' knowledge point is $D=D/S$. According to the result of data analysis, the score rate of knowledge points of students can be obtained. For example, as shown in Figure 2, it can be seen that students do not have a good command of 1.1 knowledge points and 1.3 knowledge points in chapter 1. Therefore, corresponding intervention questions can be found from the question bank for recommendation in the intervention link. The follow-up intervention is carried out according to the situation of knowledge points score of students.

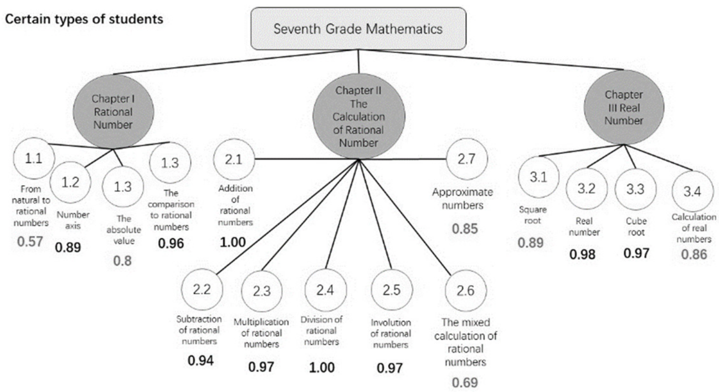

Figure 2. Diagram of Students' Knowledge Mastery

3.3 Implementation and Effect Analysis of Intervention

The implementation of the intervention is also an important part of the study. In this study, the iterative experiment method was adopted to conduct multiple interventions of different degrees to the experimental class. The first intervention was based on the student's midterm exam, and the recommended test questions for each subsequent intervention were determined by basing on the student's learning results after the previous intervention. At the end of the intervention, the students were tested and their scores and psychological data were collected and analyzed. The effect of personalized intervention was judged by the change of students' grades and psychological factors. SPSS was used to analyze the psychological data of students. Finally, the intervention effect is presented to teachers and learners.

4. Experimental methodology

4.1 Participants

The experimental participants in this experiment are 152 students in Class 3, Class 4, Class 8 and Class 9 of grade 7 in a middle school in Wenzhou, Zhejiang province. These four classes are parallel classes. They are randomly generated from primary school graduation to junior high school, with a total number of 38 students. Class 3 and 9 are experimental groups, while Class 4 and 8 are control groups. In the experimental group, the combination of the collaborative filtering algorithm and knowledge map in this study were used to make personalized learning recommendations. In the control group, teachers' intervention methods based on traditional teaching were used to make learning recommendations for students.

4.2 Research Tools

4.2.1 Questionnaires

Before the selection of questionnaires, researchers read a large number of literatures to sort out and classify the materials that are beneficial to the research topic, especially the non-knowledge factors that may have an impact after the personalized learning intervention. Finally, the mathematical scale including mathematical confidence, learning motivation and mathematical anxiety, learning engagement scale and self-efficacy questionnaire were selected as the dimensions of psychological measurement. The experimental group and the control group received personalized learning intervention based on collaborative filtering algorithm and knowledge map before and after the experiment, respectively, and compared their learning scores taught by teachers with the traditional teaching intervention. Among them, the former test is entitled the mid-term examination questions of this school, while the latter test is entitled the mid-term examination questions of other parallel schools, which ensures the consistency of the difficulty of the latter test and the former test questions, as well as the preciseness and accuracy of the experimental data.

A mathematical scale containing learning confidence, learning anxiety, and learning motivation was put forward by Professor Fennema, E. and Sherman in 1977. The Likert five-level scoring method was adopted (1= strongly disagree, 2= relatively disagree, 3= uncertain, 4= relatively agree, 5= strongly agree). Among them, learning confidence and learning anxiety each include 12 questions, and both the forward and reverse questions are 6 questions, with a Cronbach's alpha value of 0.89(Fennema & Sherman,1977). The learning engagement scale for middle school students compiled by Wang Sisi in 2013 was adopted, and the Likert five-level scoring method was adopted (1= strongly disagree, 2= strongly disagree, 3= uncertain, 4= strongly agree, 5= strongly agree). Its Cronbach's alpha value was 0.94(Pintrich et al.,1991). Among them, self-efficacy scale was proposed by Professor P.R. in 1991. It adopted Likert five-level scoring method, with a total of eight questions and positive descriptions. And Cronbach's alpha value was 0.93(Wang Sisi,2013).

4.2.2 "Sea of Clouds" learning platform

In this experiment, quasi-experimental design was used. Data-driven personalized learning intervention was adopted by 76 students in the experimental group. Through background data analysis, the personalized learning intervention was carried out via a tablet. A control group of 76 students received traditional teachers' intervention.

Data collection is the prerequisite for personalized intervention. The data collected in the experiment mainly include the data of student status, the data of answering questions at ordinary times and the data of pre-test. The student status data is the basic personal information of students, such as gender and age, which comes from the student archives of the Office of Academic Affairs. Based on the "Sea of Clouds" platform used by the school, students' learning situation, usual homework scores, homework corrections, homework time, accuracy rate, problem solving amount and ranking, etc., can be collected, which was shown in Figure 3. The pre-test measured experimental data mainly comes from the Sea of Clouds platform. Through the communication with the math teacher, the complete data of the text can be obtained, including the total score, the score of each item, each level personnel distribution, and score points for each question as well as the to-be-cared objects. The pre-test knowledge level of students can be specifically mastered.

Figure 3. Data of "Sea of Clouds" Platform

4.2.3 Analysis Method of Experimental Data

In this study, SPSS was used to process pre-test and post-test data, independent sample T and ANOVA independent sample was conducted the significance test were used, and Pearson was used for correlation analysis to analyze the correlation between personalized intervention and non-knowledge factors, so as to provide value for future research.

4.3 The Experimental Process

The two groups of classes in the experiment adopted different teaching intervention methods respectively. The data-based personalized intervention was used by Experimental group, in which the KNN algorithm and knowledge map were used to gain the score of each student on each topic and to determine the weakness of students, and to push the topics conforming to the weakness from the intervention question bank to students, with a total of two weeks and three times of intervention.

In the control group, the teacher intervention method based on traditional teaching was adopted. Through communication with math teachers of the school, three specific papers of the three times of intervention were determined and given to the students of the control group class for intervention. At the end of the intervention, students in both groups were tested on a mathematical confidence, motivation and anxiety scale. The specific process of the experiment is shown in Figure 6.

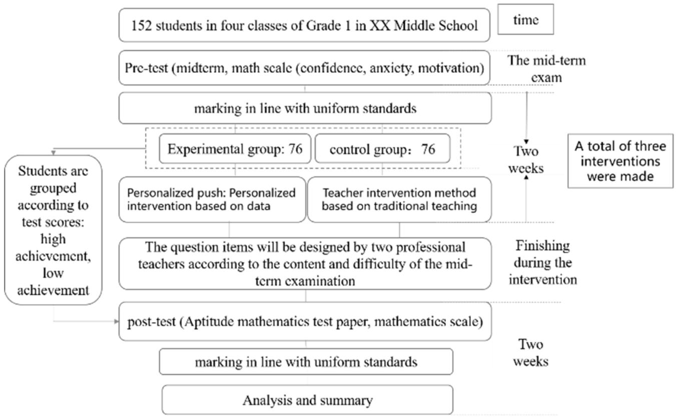

Figure 6. Flow Chart of Experiment

5. Research results

The data results of this study were discussed and analyzed from two aspects: on the one hand, the effectiveness of personalized learning intervention was verified by ANOVA two-factor independent sample analysis; on the other hand, the influence of personalized learning intervention on non-knowledge factors was verified by ANOVA independent sample test and Pearson correlation test. This study hopes to view the effect of personalized learning intervention from more stereoscopic, intuitive and accurate perspectives

5.1 Influence of Learning Intervention on Academic Grades

In this study, the math scores of the mid-term examination were used as the basis for the pre-test. The pre-test results were obtained through the independent sample T. The result showed that the average score of the experimental group was 80.8, standard deviation was 11.89, and the average score of the control group was 81.71, standard deviation was 12.944, $t= -0.81$ and $p>.05$. It was found that there was no significant difference between the experimental group and the control group in the overall knowledge level before the experiment. Then, according to the principle of statistical classification, the top 27%, the bottom 27% and the middle 46% of the experimental groups were divided into students with high, low and moderate knowledge.

After the experiment, two-factor independent sample ANOVA was used to analyze the post-test scores. The results are shown in Table1. Different intervention methods have significantly different effects on students' scores. According to the post-test data, $F(1,146)=41.789$, $P=.000$, $\eta^2=.223$, compared with the result without adopting personalized intervention (M=31.31,SD=10.09), students achieved better performance with the personalized intervention (M=41.28,SD=9.74). There is a significant difference between the knowledge level and post-test scores $F(2,146)=23.716$, $P=.000$,$\eta^2=.245$. Students with high level of knowledge (M=42.50, SD=9.83) scored higher than students with medium level of knowledge (M=37.61, SD=9.85) and also higher than students with low level of knowledge (M=27.95, SD=9.65). The cause of this result may be personalized intervention was carried out three times, although the effectiveness of personalized intervention can be proved, due to fewer times and tight time, great process cannot be achieved among the middling and low knowledge level students. Therefore, there is still some significant score differences among different levels of knowledge of students.

Table 1. Post-test results

Source	Class III Sum of squares	df	Average square	F	Significance	η^2
Intervention Method	3150.903	1	3150.903	41.789	.000	.223
Knowledge level	3576.337	2	1788.169	23.716	.000	.245
Intervention mode * Knowledge level	179.556	2	89.778	1.191	.307	.016
Error (between groups)	11008.327	146	75.400			

Note. $^{*}p < .05$.

5.2 Impact of Learning Intervention on Learning Confidence

This section explores whether there is a significant difference in the impact of learning intervention on students' learning confidence. According to the test results of the independent sample T, the average score of the experimental group was 43.03, standard deviation was 10.29, and the average score of the control group was 42.14, standard deviation was 10.70, t=0.48 and p>.05. This result proves that there is no significant difference in students' learning confidence between the experimental group and the control group before the personalized learning intervention, which ensures the scientific nature of the post-test results.

After the experiment, a two-factor independent sample ANOVA was used to analyze the post-test results of students' confidence, as shown in Table 2. According to the results of the Students' Post-test Confidence, the intervention had no significant impact on students' confidence, indicating that the intervention had no impact on students' confidence (F (1,139)=.002, P =.967, η^2=.000. The possibility of this result is that personalized learning intervention is more inclined to the guidance of knowledge points while ignoring the mastery and guidance of psychological state. Therefore, the personalized learning intervention has no direct effect on students' confidence. While there is significant difference F (2,139)=.7.368,p=.001,η^2=.096 among students with different levels after test. So after the comparison to the students with different levels of knowledge, the results showed that the personalized learning intervention reduces the confidence of low level students. However, the post-test results of the students with medium knowledge level (M=41.59, SD=11.41) and high knowledge level were higher than those of the pre-test (M=44.01, SD=10.02), proving that the personalized learning intervention has the potential to improve the confidence of students with medium knowledge level and high knowledge level.

Table2. Post-test of Students' Confidence

Source	Class III Sum of squares	df	Average square	F	Significance	η^2
Intervention Method	.163	1	.163	.002	.967	.000
Knowledge Level	1408.906	2	704.453	7.368	.001	.096
Intervention mode * Knowledge level	510.903	2	255.451	2.672	.073	.037
Error (between groups)	13290.065	139	95.612			

Note. $^{*}p < .05$.

5.3 The Influence of Learning Intervention on Learning Anxiety

Two factor independent sample ANOVA was used to analyze the influence of different intervention methods on learning anxiety of students with different knowledge levels. According to the test results of the independent sample T, the average score of the experimental group was 42.88 with standard deviation of 8.95; the average score of the control group was 41.711 with standard deviation of 9.911, t=0.69 and p>.05. Therefore, there was no significant difference in learning anxiety between the two groups before the experiment.

After the experiment, the post-test results of learning anxiety were also analyzed using a two-factor independent sample ANOVA, as shown in Table 3. According to the results of the "Learning Anxiety Posttest", $F(1,139)=.102$, $P=.750$, $\eta^2=.001$. Learning intervention has no significant effect on learning anxiety. While there is a significant difference $F(2,139)=7.378, p=.001, \eta^2=.096$ in learning anxiety of students with different knowledge levels after experiment. Therefore, this study carried out the comparison in the learning anxiety of students with different levels of knowledge. The results found that students with low levels of knowledge (M = 34.79, SD = 6.99) is significantly less than the students with mid-level knowledge (M = 42.48, SD = 9.69, p =. 017). Students with low levels of knowledge is significantly less than the students with high level of knowledge (M = 46.81, SD = 7.6, p =. 002), and there is no significant difference (p =. 72) between students with mid-level knowledge and students with high levels of knowledge. Compared with the pre-test result of students with low levels of knowledge (M = 42.66, SD = 7.63), illustrating that the personalized learning intervention significantly lowered the learning anxiety of students with low knowledge level, and compared with the pre-test results, there is no obvious difference among the mid-level students (M = 40.97, SD = 10.39), but there is a certain increase in the students with high level of knowledge (M = 44.00, SD = 11.45).Therefore, the personalized learning intervention has the most significant effect on reducing learning anxiety of students with low knowledge level, but has no obvious effect on students with medium knowledge level, and also can cause learning anxiety of students with high knowledge level.

Table 3. Post-test of Students' Anxiety

Source	Class III Sum of squares	df	Average square	F	Significance	η^2
Intervention Method	8.738	1	8.738	.102	.750	.001
Knowledge Level	1269.614	2	634.807	7.378	.001	.096
Intervention mode * Knowledge level	265.666	2	132.833	1.544	.217	.022
Error (between groups)	11959.026	139	86.036			

Note. $^*p < .05$.

5.4Correlation Analysis between Personalized Learning Intervention and Non-knowledge Factors

The correlation analysis is mainly used to study the correlation between two or more variables, and is mainly divided into positive correlation, negative correlation and zero correlation. The strength of correlation is represented by correlation coefficient r, which ranges from 0 to 1. The smaller the value is, the lower the correlation between variables is, and vice versa. This study explores the intellectual factors of the personalized learning intervention for junior middle school students and the influence of non-intellectual factors, thus clarifying the relationship between the personalized learning intervention and non-intellectual factors is of necessity. In this study, the non-intellectual factors are mainly selected from students' self-efficacy, learning engagement, learning motivation, learning anxiety and learning confidence. Therefore, in the process of data analysis, the relationship between the personalized learning intervention and six variables is analyzed by Pearson correlation, and the results are shown in Table 4.

Table 4. Correlation Matrix of Personalized Learning Intervention and Factors

	1	2	3	4	5	6
I Grades	-					
II Learning Engagement	.15	-				
III. Self-efficacy	$.27^{**}$	-.02	-			
IV. Learning anxiety	$.26^{*}$	$.31^{**}$	.13	-		
V. Learning Confidence	$.30^{*}$	$.34^{**}$	.15	$.89^{**}$	-	
VI. Learning Motivation	$.24^{*}$	$.35^{**}$	$.25^{**}$	$.63^{*}$	$.67^{**}$	-
VII. Personalized Learning Intervention	$.46^{**}$	$-.14^{*}$	$.41^{**}$	$-.16^{*}$	$.17^{*}$	.01

The results showed that achievement [r(143)=.46, P =.00], self-efficacy [r (143)=.41, P =.00] and learning confidence [r (143)=.17, P =.04] were significantly positively correlated with the personalized learning intervention, while learning anxiety [r(143)=-.16, P =.05] and learning engagement [r (143)=-.14, P =.05] were negatively correlated with the personalized learning intervention, and learning motivation [r (143)=.01, P =.95] were not correlated with the personalized learning intervention. It can be concluded that the personalized learning intervention can improve students' academic grades, self-efficacy and learning confidence, but it has a negative effect on learning anxiety and learning engagement, and has no relationship with learning motivation. It may be caused by the reason that the personalized intervention question items are a little difficult, thereby increasing the psychological burden of students.

5.4 Summary

Through data analysis, it is found that technology-supported personalized learning intervention can effectively improve students' academic performance (Chen,2018; Chen,2009; Acheson,2018). In terms of learning confidence, there is no significant difference in the influence of learning intervention methods on students' learning confidence. However, individualized learning intervention reduces the learning confidence of students with low knowledge level. The reason for this result may be that in the process of personalized learning intervention for students with low knowledge level, because of the low difficulty of the intervention questions for these students, the questions in the initial intervention were relatively simple. However, due to the limited number of interventions, in order to achieve the final learning goal, it is difficult to intervene in the post-test questions, which leads to the decrease of students' learning confidence. In terms of learning anxiety, the study found that there was no significant difference in the influence of learning intervention methods on students' learning anxiety. However, personalized learning intervention obviously reduces the learning anxiety of students with low knowledge level and increases the learning anxiety of students with high knowledge level. This result is not surprising. First of all, because learning anxiety is a long-term psychological factor affected by many aspects. After a limited number of personalized interventions, learning anxiety cannot be significantly affected. Secondly, personalized learning intervention will recommend relatively simple questions to students with low knowledge level and relatively difficult questions to students with high knowledge level, thus resulting in such a result. In previous studies of personalized intervention, learning anxiety has rarely been measured (Xie et al.,2019).

In general, after individualized learning intervention for junior high school students, it was found that learning intervention methods had an impact on students' academic performance, and also had an impact on non-knowledge factors related to learning elements. However, the effects of individualized learning intervention on learning confidence and learning anxiety of students with different knowledge levels are different. This finding makes us believe that students' learning state is multifaceted, so we should treat the theory of "achievement" with caution, and use the perspective of development to treat students, so as to promote their all-round development. In addition, personalized learning interventions do not necessarily have a positive impact on all students. Different interventions may be more appropriate for students at different levels of knowledge.

6. Conclusions and Discussions

Learning intervention attaches great importance to the personalized learning. Effective methods and means can provide learners with targeted learning resources and promote the development of education and teaching. In the traditional teaching, teachers' one-to-more tutoring is difficult to ensure that each student has a clear grasp of the learning situation. The introduction of electronic devices in the classroom has improved this phenomenon, however, many teaching AIDS cannot really achieve personalized resource recommendation and evaluation. Compared with the traditional teaching intervention, the personalized learning is very convenient for calculating students' scores, organizing students to understand conceptual knowledge, and can also help teachers understand and improve students' learning situation (Wongwatkit et al.,2017). In this thesis, two kind of jobs are conducted. Firstly, the author proposed a novel learning intervention method basing on knowledge map and collaborative filtering algorithm, and designed a research framework. Then, according to the existing research framework, this method is applied to teaching experiments, and the data of students are collected to explore the impact of learning intervention on students. According to the experimental results, the intervention the author proposed is effective and improved students' grades. In addition, the personalized learning intervention also has an impact on students' psychological-related factors. The personalized learning intervention can improve the sense of self-efficacy and has the potential to enhance students' learning motivation. Meanwhile, the improvement of learning motivation also enables students to be willing to spend time and energy in learning and improving their executive ability in the learning process (Muñoz-Restrepo, Ramirez, & Gaviria,2020). However, it should be noted that the personalized learning intervention can enhance students' learning anxiety, which may be caused by the psychological burden of students due to the difficulty of personalized topics. Perhaps the personalized learning with high pertinence will increase students' learning anxiety (Bulger,2016). As the limitation of time and scale, two aspects need to be improved in this study. First, the number of study sample is not large enough; second, although the study has found changes in students' psychology, it has not had enough time to conduct psychological intervention for students. The continuous improvement in the following research is expected to conduct and the impact of personalized learning intervention on students should be explored.

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Preparing SQA Professionals: Metamorphic Relation Patterns, Exploration, and Testing for Big Data

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Abstract

Purpose – Metamorphic Computer science (CS) has been rapidly growing in popularity, partly due to the great growth of big data (BD) and other new technologies, and the services that support them. BD involves data sets that are too large to be captured, curated, analysed, or processed (for an acceptable time and cost) using traditional CS techniques. Although BD has changed our way of living and working, it may still frequently encounter software quality assurance (SQA) problems — when testing BD systems, it may be too difficult to check whether the system behaves correctly or produces the correct output. This situation is known as the Oracle Problem, and is a major challenge for current and future (student) SQA professionals.

Metamorphic testing (MT) has been identified as an effective approach to alleviating the Oracle Problem. MT makes use of metamorphic relations (MRs) across multiple test case executions to help to identify program faults. Metamorphic exploration (ME) is a related approach that can enable a better understanding, and thus testing, of a system. Both MT and ME rely on MRs for their successful implementation. However, identification of MRs is often a manual task requiring creative thinking, and a good understanding of the system. Metamorphic relation patterns (MRPs) are abstractions, or templates, for multiple actual MRs.

This paper reports on an experience using MRPs to guide the identification of MRs for the implementation of ME/MT as a step towards training the next generation of SQA professionals.

Design/methodology/approach – The ME/MT experience is examined through reflection and comparison with existing MRP studies reported in the literature. Our case study involved using MRPs to identify MRs for ME/MT of BD systems. In addition to MRP-derived MRs, other MRs were derived directly from the user perspective, or from previous studies in the literature. The future use of MRP as a pedagogical tool to help train CS students and SQA professionals is examined.

Findings –We found that MRPs are useful in guiding, teaching and training the identification of MRs for MT/ME. Testers and students are able to implement MT/ME easily since the identification of MRs is a vital step in conducting MT/ME.

Originality/value/implications – This is, we believe, the first report on using MRPs to support ME/MT as a step towards training and teaching SQA professionals. We highlight the importance of BD SQA, and how MT/ME can support this. We show the usefulness of ME to prepare for MT, and MRPs to prepare good MRs to support MT/ME. We also outline several directions for follow-up action, relating to both MRP-based research and training.

Keywords: software quality assurance; big data; metamorphic testing; metamorphic exploration; metamorphic relation; metamorphic relation pattern;

1 Introduction

Computer science (CS) has been experiencing a rapid expansion in popularity, which motivates the demand for CS-related education and training. This may be partly caused by the development of big data (BD) together with the services that support it. BD involves data sets that are too large to be captured, curated, analyzed, or processed (for an acceptable time and cost) using traditional CS techniques. According to Laney (2001), BD has been described as having three main properties of big volume, variety and velocity, also known as the 3Vs model. BD has been changing people's way of living, working and thinking (Armstrong, 2014). Towey (2014) pointed out that due to the growing ubiquity of BD systems, companies are seeking workers with BD development skills, which motivates the increasing numbers of potential workers looking for ways to develop the related skills. Software testing is a major element of any software quality assurance (SQA) education and training. Basically, software testing consists of execution of a system under test (SUT) to check whether its behavior or output is correct. The mechanism used to determine correctness is called a (test) oracle. However, sometimes it is impossible or too expensive to implement an oracle, which is a situation referred to as the (test) oracle problem: systems facing the oracle problem have been called "untestable systems" (Segura et al., 2018). BD systems are typical examples of untestable systems because there is no precise functional specification for checking whether the behavior or outputs are as expected. Also, it is typically too expensive to check the behavior or outputs of BD systems due to the huge size of the data involved. Therefore, testers skilled in addressing the oracle problem for BD systems are in urgent demand (Davoudian & Liu, 2020).

Metamorphic testing (MT) is a well-developed property-based software testing technique that uses metamorphic relations (MRs) to identify possible faults in the SUT. Many studies have reported on MT being an efficient approach to alleviate the oracle problem (Chen et al., 2018; Segura et al., 2016; Zhou et al., 2018). MRs are an essential part of MT, and are used to illustrate the relation between at least two sets of test cases, the *source* and *follow-up* test cases. To conduct MT, firstly, source test cases are generated and then a pre-defined MR can be used to generate the follow-up test case(s) based on the source test case(s). Secondly, these test cases are run against the SUT, and the source and follow-up outputs are compared with the MR to check whether or not there has been a violation, which would indicate a software fault. Recently, an addition to the MT literature is metamorphic exploration (ME) by Zhou et al. (2018), which constructs MRs from the perspective of users. It enables testers and users to have a better understanding, and thus testing and use, of a system. More recently, ME has been identified as a means to scaffold the teaching and training of MT (Zhou et al., 2018; Towey et al., 2019; Yang et al., 2019).

The performance of MT is strongly influenced by the quality of MRs used (Chen et al., 2018; Segura et al., 2016). However, identification of appropriate MRs is still a major challenge, and requires creative thinking, and an adequate understanding of the SUT, especially for good MRs (Chen et al., 2018; Segura et al., 2016). Metamorphic relation patterns (MRPs) are abstractions, or templates, for various real MRs, and have been proven effective at helping to identify appropriate concrete MRs.

This paper reports on an experience using MRPs to guide the identification of likely MRs for the implementation of ME and MT as a step towards training the next generation of SQA professionals.

2 Background: MRs and MRPs

Generally, in MT, MRs are constructed based on the specifications of the SUT. However, as reported by Zhou et al. (2018), in ME, MRs need not be necessary properties of the SUT, but are properties hypothesized by users, which are so-called hypothesized MRs (HMRs). These HMRs are used for exploring the SUT, for the aim of better understanding its performance. However, the identification of likely MRs is still a challenge for testers especially beginners since it is often a manual task requiring creative thinking, and a good understanding of the system (Chen et al., 2018; Segura et al., 2016).

Recently, Segura et al. (2017) introduced the term *metamorphic relation output pattern* (MROP), which they defined as an abstract relation among the source and follow-up outputs from which multiple concrete metamorphic relations can be derived. Their work opened a new MT research direction on "metamorphic relation patterns," in a broad sense, as foreseen by Segura in his keynote at the third International Workshop on Metamorphic Testing (ICSE MET '18) (Segura, 2018).

More recently, Zhou et al. (2018) further investigated the notion of "patterns" and formally defined the general concept of a *metamorphic relation pattern* (MRP) as "an abstraction that characterizes a set of (possibly infinitely many) metamorphic relations." Zhou et al. also defined a concept of a *metamorphic relation input pattern* (MRIP) as "an abstraction that characterizes the relations among the source and follow-up inputs of a set of (possibly infinitely many) metamorphic relations."

3 An MT/ME Experience

3.1 System under test (SUT)

Electronic commerce website: Our target SUT category for ME and MT was websites or services used for electronic commerce (e-commerce). Typically, these services may provide access to very large amounts of data, including product information for potential purchases. The servers examined belong to Amazon in English and Chinese (Deloitte, 2017).

3.2 SUT Metamorphic Relation Patterns

In this study, we used MRPs and from Zhou et al. (2018) and from Segura et al. (2019) to construct new MRs.

Zhou et al. (2018) proposed a *symmetry* MRP together with a *change direction* MRIP that can be applied to different kinds of applications. These two patterns are defined based on the notion of symmetries in various areas, such as real-life nature and mathematics. The symmetry MRP leads to new MRs by using different viewpoints of the SUT from which the SUT should look the same. For instance, a query "sweaters for women" on online commerce websites should return the same number of outputs, regardless of whether the outputs are sorted by price from low to high or from high to low. The change direction MRIP constructs MRs by modifying the direction element in the source test cases to generate follow-up test cases. In the previous example, the direction in the source test case is price from *low to high*, while the direction in the follow-up test case is changed to *high to low*, thus enabling the MR to be defined.

A query represents how to retrieve and display data. Segura et al. (2019) refer to software systems that support the use of queries as query-based systems. In such systems, users can enter queries for searching information, and sorting or filtering results by specific criteria. For example, a query "sweaters for women" sorted by price from low to high on an e-commerce service like Amazon. Segura et al. (2019) presented seven MRPs for query-based systems, as follows:

- **Input equivalence**: The source and follow-up test cases should return the same outputs for inputs that accept fully equivalent values expressed in different forms: (1 dollar = 100 cents) should return same outputs.
- **Shuffling:** If the ordering criterion in the source and follow-up inputs changes, then the source and follow–up outputs should contain the same items. For instance, a query "sweaters for women" in Amazon ordered by "price from low to high" should contain the same items compared with the same query ordered by "price from high to low".
- **Conjunctive conditions:** If a series of new conjunctive conditions are added into source inputs to construct follow-up inputs, then the source outputs should include the follow-up outputs. For instance, a query "sweater" in Amazon should contain the items that searched through the same query filtered by a specific brand like "ZESICA".
- **Disjunctive conditions:** If a series of new disjunctive conditions are added into source inputs to construct follow-up inputs, then the source outputs should be included in the follow-up outputs. For instance, the outputs of query "software" in Google should be included in the outputs of query "'software' OR 'application'".
- **Disjoint partitions:** Suppose the input domain of at least one parameter of the source and follow-up inputs can be divided into different partitions, this MRP represents the relation that the source and follow-up outputs should be pairwise disjoint. For example, a query "sweater" filtered by a brand such as "LEANI" in Amazon should contain totally different items compared with the results of the same query but filtered by different brand such as "ZESICA".

- **Complete partitions:** Suppose the input domain of at least one parameter of the source and follow-up inputs can be divided into different partitions, this MRP represents the relations that the source outputs should contain all the follow-up outputs. For example, a query "sweater" in Amazon should contain all the items searched through the queries "sweater" filtered by "Women's Fashion" and "Men's Fashion".
- **Partition difference:** Suppose the input domain of at least one parameter of the source and follow-up inputs can be divided into different partitions, this MRP represents the relations that the follow-up outputs are pairwise disjoint to each other and their union contains the same items as the source outputs. For example, a query "sweater" filtered by a brand such as "LEANI" in Amazon should contain totally different items compared with the results of the same query but filtered by a different brand such as "ZESICA", and these two outputs should be same as the results searched using the same query filtered by "LEANI" and "ZESICA".

3.3 SUT Metamorphic Relations

A total of five HMRs were used in the ME/MT study for the e-commerce sites.

- **HMR1**: This HMR was inspired by the symmetry MRP, and states that an online commercial server should return equivalent outputs for the same input and sorting rule, regardless of the time it is running. We consider that this HMR can be easily identified on the basis of the input equivalence pattern.
- **HMR2**: This HMR was also inspired by the symmetry MRP, and states that an e-commerce server should return equivalent amounts of outputs for the same input regardless of what sorting rule is used. In this study, the default and the "sort by price" sorting rules were used. We consider that this HMR can also be easily identified on the basis of the shuffling pattern.
- **HMR3**: This HMR was inspired by the complete partitions pattern, and states that if a user uses search functions and obtains a number of corresponding outputs, *S1*; then if the outputs are further filtered by a specific criterion, obtaining a number of corresponding outputs, *S2*; then *S1* should be greater than or equal to *S2*.

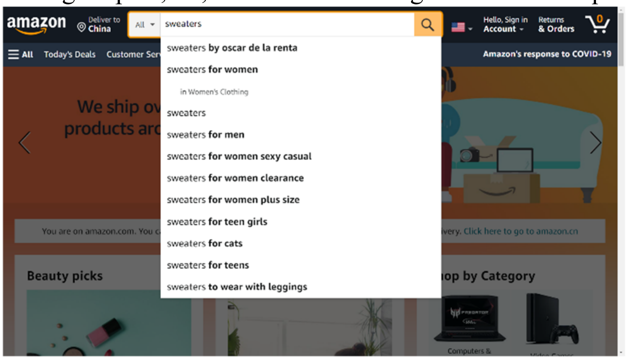

Fig. 1. Recommendation list from English Amazon web server.

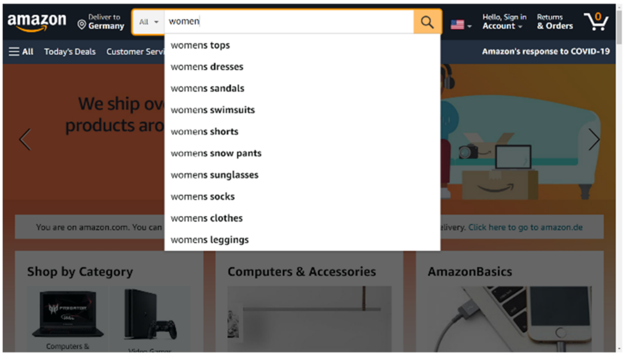

Fig. 2. Recommendation list from English Amazon web server.

- **<u>HMR4</u>**: This HMR was constructed by exploring the ways and habits of users on the e-commerce system. Related to different input languages (e.g., Chinese compared with English), an input query may be changed simply by the word order, or through some additional grammatical changes. English input queries, for example, may involve a change to the structure: "sweaters for women" compared with "womens sweaters". Figs 1 and 2 illustrate this with recommendation lists from English Amazon. HMR4 states that if a query is slightly changed to construct a new query without changing its original meaning, then the new result should contain the same or similar items compared with the original one. We consider that this HMR can also be easily identified on the basis of the input equivalence pattern.
- **<u>HMR5</u>**: This HMR was also constructed by exploring the ways and habits of users on the e-commerce system. E-commerce servers typically offer several ways for users to search for goods, including (1) searching for items through a query only, and (2) searching for items with a query and a filter function. The filter offers many types of the items to users. Each type has several possible values. Users can select some of these values for further details of goods. HMR5 is: If a user searches for the same item using the search and filter functions with the same inputs, the results should be similar to each other. We consider that this HMR can also be easily identified on the basis of the symmetry MRP and the input equivalence pattern.

4 Evaluation and Discussion

In our exploration of both the English and Chinese versions of Amazon, we found that all hypothesized MRs (HMR1-5) were violated.

A typical example of violation on the English version of Amazon is shown in Figs. 3 and 4. The source output shown in Fig. 3 is over 300,000 items, but when the same input query was repeated at a different time, the new result (shown in Fig. 4) was over 400,000. Note that this experiment has been repeated many times on different days. Since these two queries are totally the same and the difference is not a small number, this is an apparent violation.

Fig. 3. HMR1 source test case for English Amazon web server.

Fig. 4. HMR1 follow-up test case for English Amazon web server.

Towey (2015; 2016) reported that many CS students complain that the materials they use in class and independent learning may appear too theoretical, and they prefer more practical and useful things. This reflects the tensions existing in education and training methods, such as traditional higher education and vocational and professional education and training (Towey, Walker, & Ng, 2018; 2019). In this study, we combined the education and training of SQA with software testing. We used the MRP to guide and train the identification of MRs for MT/ME. Through the implementation of MRPs, the ability to identify MRs was improved. Testers, especially beginners, should thus more easily be able to implement MT/ME since the identification of MRs is a vital step of conducting MT/ME and MRPs can support identifying a specific type of MRs.

MRPs, we argue, can not only guide and train the identification of MRs for MT/ME, but can also offer students a way to better understand and use the SUTs, especially those MRPs that can only be applied to a specific area. Because an MRP is an abstraction among a series of MRs, and in MT, the MRs generally are constructed based on the specifications of the SUT, MRPs can be regarded as a high-level abstraction among these specifications and are able to help the students better understand and use these specifications, especially the students who are new to the SUT.

5 Conclusion and Future Work

Given the growing popularity of BD systems, the need of testers to be able to apply appropriate SQA techniques is increasingly urgent. The performance of MT for testing untestable systems has been recognized, and MT has been rapidly growing in popularity. However, there is still a need to provide appropriate education and training to ensure good understanding and implementation. ME has been shown to facilitate this adoption. In this study, we have reported on an experience using MRPs to guide the identification of MRs for the implementation of ME/MT as a step towards training the next generation of SQA professionals.

This is, we believe, the first report on using MRPs to support ME or MT and train SQA professionals. In this study, a case study involved use existing MRP studies reported in the literature to identify MRs for ME or MT of BD systems. Except the MRP-derived MRs, other MRs used in this study were derived directly from the user perspective or previous MT related studies. A popular BD system has been explored and tested.

In this paper, we have highlighted that the BD SQA is an indispensable part in CS, together with how to use MT to support this. We have shown the use of ME to prepare for MT, and MRPs to construct good MRs for both ME and MT. Since the identification of MRs is a vital step in the implementation of MT and ME, we believe that based on the using of MRP, students should be better able to conduct the MT and ME.

During reflection, we found that the relations used in our study, that were derived from previous literature or users' perspectives, could be easily identified based on existing MRPs. This further supports the idea that MRPs can offer testers a direction and guideline to identify a certain type of MRs, especially those MRPs that can only be applied to a specific area. Although their application scope is limited, on the other hand, they may be able to offer both beginners and experts a more detailed and in-depth guideline for a certain type of systems.

Our future work will include the exploration and use of more MRPs to guide the identification of MRs for MT and ME. Furthermore, more MRs are also required to further validate our findings. Based on the potential for MT and ME to teach and train SQA of so many current and future systems such as BD systems, it is predicted that the positive impact of MRP's inclusion in MT and ME education and training should be able to broaden the popularity and influence of MT and ME.

Acknowledgements

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Research on a Personalized Recommendation of MOOC Resources Based on Ontology

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Abstract

Purpose – With massive learning resources, it is a key issue for MOOC platforms to provide a recommendation services and help learners to find suitable content efficiently. However, there were problems in the process of personalized recommendation of learning resources, such as a cold start (i.e. difficulty in recommending resources to new users) and over-specialized recommendations. This study aims to establish an effective personalized recommendation model for MOOC by linking the characteristics of users and MOOC resources to provide learners with effective MOOC learning support.

Design/methodology/approach – This study proposes a personalized recommendation model for the recommendation of MOOC resources that combines a calculation of semantic similarity and an analysis of user characteristics. The method is based on the construction of a MOOC resource ontology and a learner ontology. By calculating the hierarchical correlation and attribute correlation among MOOC ontologies, we analysed the semantic correlation among MOOC resources and combined the user ontology characteristics to personalize the recommendation of MOOC resources. Finally, we used simulation experiments to verify the effectiveness of the recommendation method.

Findings – This study showed that the recommendation scheme matches the user preferences and personal characteristics through simulation experiments. On the one hand, we found that the construction of a user ontology can solve the problem of a cold start to a certain extent. On the other hand, we found that using a semantic similarity calculation based on the combination of the hierarchical correlation and attribute correlation can avoid the problem of over-specialized recommendations.

Originality/value/implications – This study formed an effective model for the personalized recommendation of MOOC resources. It provides a new idea for connecting MOOC learners and resources, and helps to solve the problems which exist in the current process of learning resource personalization recommendations (i.e. relying on user scores, over-specialized recommendations, and a static knowledge structure of recommended resources). In follow-up research, it is necessary to further optimize the construction of learner ontology and MOOC resource ontology. In the process of personalized recommendation of MOOC resources, this study only considers the learner's occupation when analysing the characteristics of learners, and more factors should be taken into account in the follow-up study to achieve more accurate recommendations.

Keywords: personalized recommendation; ontology; MOOC resources; learner characteristics; semantic association

1 Introduction

In the information age, massive learning data and resources were generated all the time. The data value principle proposed that learning resources were provided not in large quantities, but usefulness (Zhao et al., 2018). But at present, there was a problem of low-value density in massive learning resources. The White Paper on Internet Learning in China pointed out that "Internet+ Education" had moved from the 1.0 era, which was driven by content such as video teaching, to the 2.0 era, which was based on precise services. Online courses are changing from "emphasizing resources" to "emphasizing services"(Zhan, Cai, Fang, & Mei., 2016) The individualized, precise, and efficient supply of massive learning resources were an inevitable choice for the structural reform of educational resources and service provision. How to avoid the problem of “Information overload” caused by massive resource information (Boucherryan & Bridge., 2006), efficiently obtain adaptive learning resources, release the value of massive learning resources, improve the utilization and usefulness of high-quality resources, and make personalized and intelligent recommendations to learners was particularly important.

Currently, MOOC learning faced the problem of high participation rate and low completion rate. And massive MOOC resources made learners face the danger of being lost in the information at any time during the learning process (Zhan, et al., 2015). Applying technology to education, analyzing learners' characteristics and needs with the help of educational data mining technology and learning analysis technology, and providing personalized learning resources for learners was one of the necessary ways to realize high-quality online learning and promote online education to return to the educational essential characteristics of "people-oriented" (i.e. realizing people's all-round development). In this study, we analyzed the characteristics of learners and learning resources and used Protégé to construct the Learner Ontology model and the MOOC resource ontology model. Based on the MOOC resource ontology model, we performed the semantic relevance degree of MOOC resources, calculated the relevance degree of attributes and levels of MOOC resources, and recommended personalized learning resources to each learner by combining their characteristics. It not only matched learners with suitable information among the massive and open educational resources but also supported ubiquitous, adaptive, and personalized learning.

2 Literature Review

Recommendation strategy selection was the key to the personalized recommendation. Nowadays, a series of mature personalized recommendation strategies had been formed, for example, content-based recommendation, collaborative filtering algorithm-based recommendation, knowledge-based recommendation, rule-based recommendation, and hybrid recommendation of multiple recommendations (Pan & Chen., 2015).

In the research of content-based recommendation, Pareek and Jhaveri (2018) modeled the multidimensional features of learning materials and learners' knowledge acquisition patterns. They recommend matching learning materials based on learners' learning styles and needs to achieve content-based personalized recommendations.

Nguyen et al. (2017) applied image classification techniques and learning object detection techniques to extract powerful features from images to achieve personalized recommendations for learning resources. Jiang et al. (2018) mined user interests and found similarities among users from historical information of user clickstreams. They combined the Leader Clustering algorithm and rough set theory to achieve user clustering based on content and perform targeted resource recommendations. In the research of collaborative filtering algorithm-based recommendation, Wang (2017) proposed personalized learning resource recommendation based on group intelligence. First, she used the idea of collaborative filtering recommendation, clustered learners with similar characteristics, and then used the ant colony algorithm to find learning resources with a high probability of selection by learners and recommend them. In the research of knowledge-based recommendation, Liu et al. (2017) constructed a learner model using interest mapping and established a knowledge-based personalized recommendation system in a cloud environment. In the research of rule-based recommendation, Intayoad et al. (2017) focused on the social context between learning objects and learners and recommended appropriate and personalized learning paths to learners by using association rules. Harrathi et al. (2018) used Bloom's taxonomy to classify MOOC learning activities and integrated them into a rule-based recommendation system to complete personalized recommendations. Learners can adjust learning activities according to their personality characteristics and needs. In the research of hybrid recommendation, Benhamdi et al. (2018) proposed NPREL, a hybrid recommendation method based on collaborative filtering algorithm and content-based analysis. It can provide students with the best learning materials based on their characteristics. Yu et al. (2017) used the credit bank constructed based on learning records as the user's information and integrated various methods such as collaborative filtering algorithm to recommend personalized learning resources to learners using hybrid recommendation.

With the development of personalized recommendation technology, researchers had taken learning situation analysis, social connection analysis, resource and learner dynamic analysis as the factors of personalized recommendation. For example, Zhao (2018) proposed personalized learning resources recommendation based on situational information, which combined the circumstances of students' current learning position, as well as the learning time and learning characteristics, to recommend the knowledge points suitable for students. Wu and Li (2017) proposed a context-sensitive learning resource relevance analysis and personalized recommendation model to explore the approach of contextual reasoning in dynamic environments. Li et al. (2019) used the matrix decomposition model, Multilayer perceptron model, and NEUMF prediction analysis model to deal with user eigenvalue matrix and education resource eigenvalue matrix to make a personalized recommendation of education resources.

Different personalized recommendation methods had their limitations. The content-based recommendation was affected by cosine similarity, and there was a problem that the recommendation result was too single Li et al. (2007). If this recommendation method was applied to the recommendation of multimedia resources, it was difficult to extract feature information. Collaborative filtering algorithm depended on the evaluation information in user interaction, which had the problem of cold start (i.e. personalized recommendation cannot be realized without user evaluation). The knowledge-based recommendations cannot adapt to the change of learners' needs because of the static knowledge structure. Rule-based recommendations required a lot of rule maintenance. In order to solve these problems, the hybrid recommendation was usually used to make up for the shortcomings of the single recommendation method.

In summary, it can be seen that constructing the learner model and learning resource model were the basis of personalized recommendation of learning resources. And the hybrid recommendation method can achieve effective recommendation. In this study, the problems of various recommendation methods were broken down one by one. Through the construction of a learner-centered and learning resource body, the recommendation based on model information can solve the problem of cold start caused by sparse data in recommendation based on collaborative filtering algorithm. By updating learners' personal information and historical records, the problem of static knowledge structure of learners in knowledge recommendation was solved. By introducing semantic association technology, the information with the semantic association was recommended, which made the recommendation results more diversified and solved the problem that the recommendation results were limited to a certain category in the content-based recommendation process.

3 Design the personalized recommendation process of MOOC resources based on ontology construction

Ontology represented the concepts and the relationships among concepts in a certain field, and it can be used as a holistic and representative description of the field. Ontology construction can provide a clear and agreed definition of the domain-specific concept in the scope of sharing, and support the communication and data sharing between human and machine, machine and machine. In the process of ontology construction, the explicit knowledge concept was used to describe the model of a specific domain, which made the information knowledgeable and easy to identify and retrieve (Song, 2015). And the general ontology construction model made the information comprehensive, representative and shared, which was beneficial to the analysis and discussion of this field.

This study used the Stanford University ontology construction seven steps Gan et al. (2011) to carry on the Learner Ontology and the MOOC resource ontology construction. The ontology construction step was shown in Figure 1.

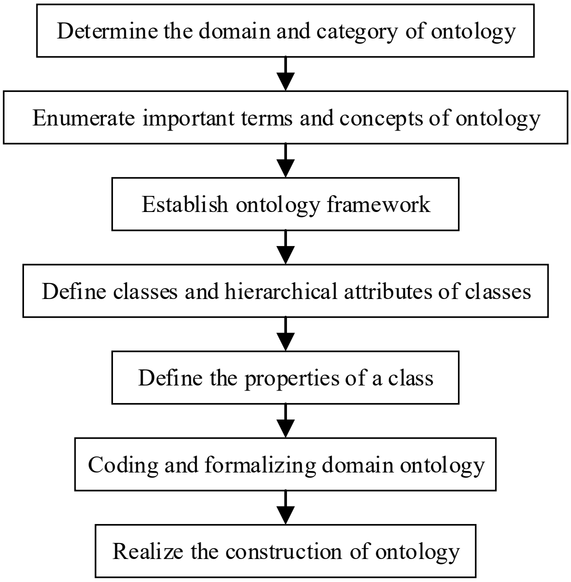

Fig. 1. Flow chart of ontology construction

We used the semantic relevance analysis method based on the ontology construction, unified the learner's characteristics, carries on the MOOC resources personalized recommendation. First, the Learner Ontology and the MOOC resource ontology were constructed. Second, the semantic relevance analysis of the MOOC resource was completed by computing the hierarchical and attribute relevance of the MOOC resource ontology based on the constructed MOOC resource ontology. And then, we analyzed the user interest degree, calculated the matching degree between the MOOC resources to be recommended and the user interest, and recommended the appropriate resources to the user based on semantic relevance. The implementation framework was shown in Figure 2.

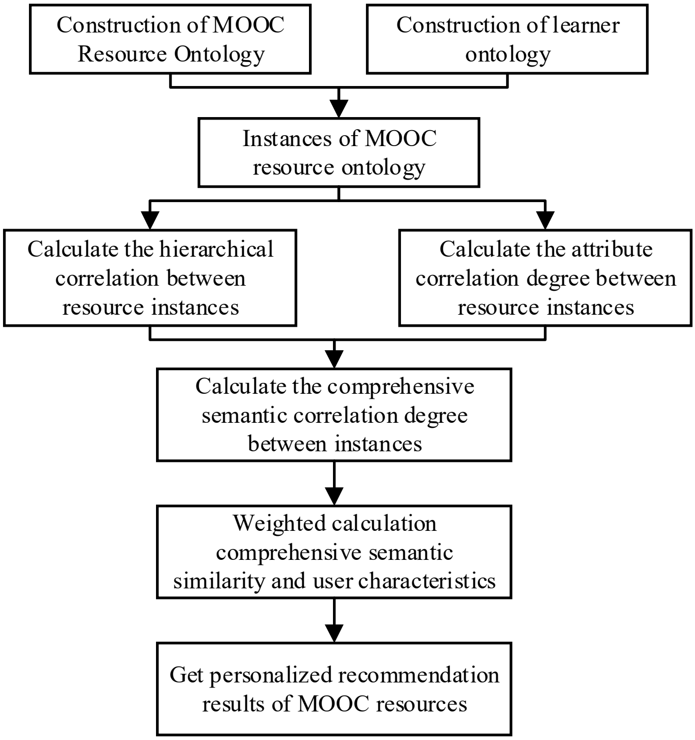

Fig. 2. Personalized recommendation process of MOOC resources based on ontology

4 Construct ontology

4.1 Constructing MOOC resource ontology

Ontology was composed of five elements: concept, relation, function, axiom, and instance, which contained a set of classification hierarchy of concepts and semantic description of concepts. In this study, the hierarchical relationship between concepts and the relationship between attributes were considered comprehensively, and the formal expression formula of MOOC resource ontology was constructed: Demo= {C, R, P, I, A}. Among them, "C" represented some concepts contained in MOOC resource ontology, which constituted a structure with a certain hierarchical relationship; "R" represented the hierarchical relationship between concepts or examples; "P" represented attribute relationship, which can connect different concepts or examples; "I" represented MOOC resource instance; "A" represented axiom, which reflected the relationship or constraint between functions in MOOC domain. Based on the analysis of the characteristics of MOOC resources, this study used Protégé 5.2 to construct the ontology of MOOC resources. Among them, the four core first-level classes of MOOC resources were “Lever”, “Type”, “Authentication” and “SubjectType”. There were 14 secondary classes and the secondary classes under “Type” were “General knowledge courses”, “Professional courses”, “Skill training courses” and “Exam courses”. The secondary classes under “Level” were “FirstStep”, “MediumDegree”, and “HigherDegree”. The secondary classes under “Authentication” were “Credit”, “Certificate”, “OtherAuthentication” and “NonAuthentication”. The secondary classes under “SubjectType” were “Natural science”, “Social science” and “Comprehensive”. There were 12 tertiary classes, as follows: the third classes under “Natural science” were “Science”, “Engineering”, “Agronomy” and “Medicine”; the third classes under “Social science” were “Philosophy”, “Economics”, “Law”, “Education”, “Literature”, “History”, “Military science” and “Management”.

The attributes of the MOOC resource ontology constructed in this study were divided into object attributes and data attributes, among which the object attributes were isCourseTypeOf (i.e. the course type), isCourseLeverOf (i.e. the curriculum level), hasAuthentication (i.e. the corresponding course certification) and hasSubjectType (i.e. the discipline types). There were two data attributes: ParticipantsNumber(i.e. the number of participants) and Score(i.e. the course grading).

The core classes, partial extension classes, and attributes of MOOC resource ontology were shown in Figure 3.

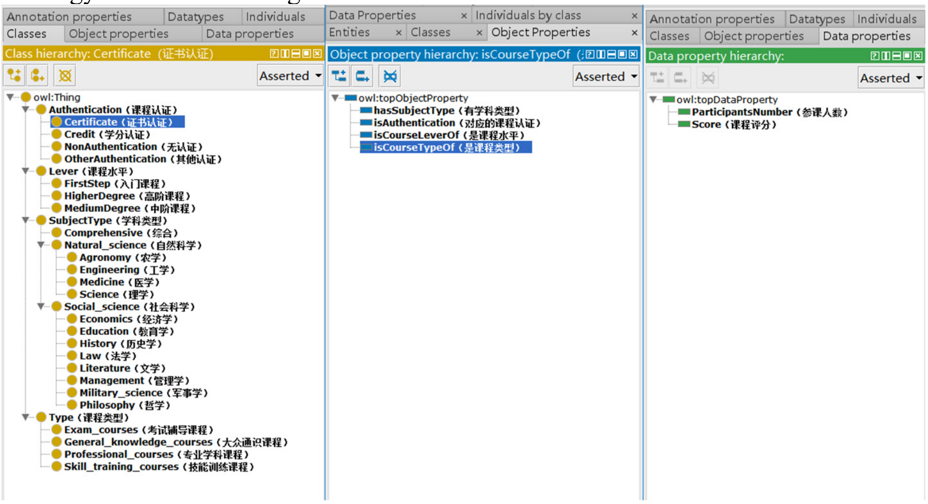

Fig. 3. Core classes, partial extension classes, and attributes of ONTOMOOC

The MOOC resource ontology fragment obtained by constructing the above-mentioned MOOC resource ontology was shown in Figure 4.

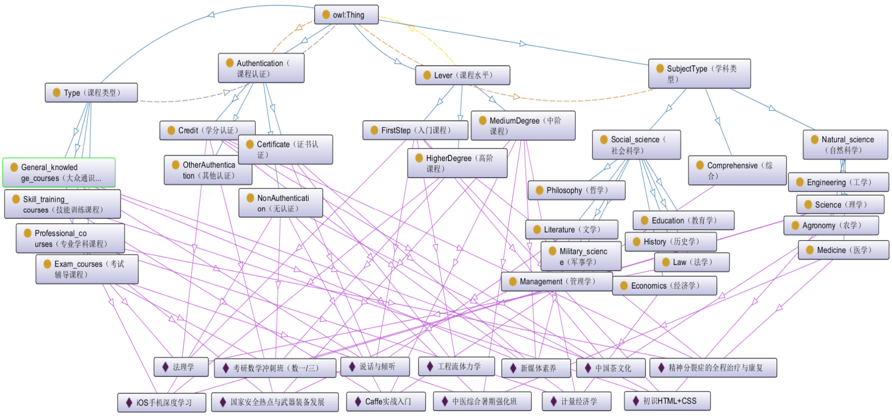

Fig. 4. MOOC resource ontology fragment

4.2 Constructing learner ontology

The learner model was described by the method of ontology construction. We analyzed and modeled the basic information of learners, their evaluated history records, and the interest courses of learners. The model was divided into three groups: User= {UserInfo, UserHis, UserOnto}.

UserInfo represented the basic information of learners, including learner number, name, gender, age, education level, major (occupation), grade (level), and hobbies, which were expressed as UserInfo= {ID, Name, Sex, Age, Education_level, Profession, Grade, Hobby}. Users need to fill in this information when they register and log in for the first time. And then the system can know the information of learners in time, which can solve the cold start problem of personalized recommendation of courses because users have no learning records for the first time.

UserHis represented the learning history of learners on the MOOC platform, including the records of related browsing and learning, and the scores of learners on courses. The learner history information model was expressed as: UserHis= {(C1, S1), (C2, S2), (C3, S3) ... (Cn, Sn)}. Among them, "C" represented the curriculum examples that learners had studied or paid attention to, and "S" represented the learners' rating of curriculum resources. Because the learner's learning record presented a real-time and dynamic learning process, the system needs to record and update the learner's learning and scoring status in real-time to grasp the learner's interest preference in time and accurately, and provide a more real-time and effective personalized recommendation.

UserInter represented the MOOC resource ontology that learners were interested in, which was expressed as UserInter= {C, R, P, I, A}. "C" represented the attribute set of MOOC resource ontology that learners were interested in. "R" represented the hierarchical relationship between concepts or instances. "P" represented the attribute relationship. "I" represented the instance set of MOOC courses that learners were interested in, and "A" represented axioms. This model was similar to the MOOC resource ontology model, in which the learner's interest ontology (i.e., the MOOC resource ontology that the learner was interested in) can be expressed as a subset of the MOOC resources to be recommended. Through the comprehensive analysis of

UserInfo and UserHis, the semantic description of UserHis in the recommended course ontology access was compared with the resources in the resource ontology Demo library, and the semantic association analysis, the MOOC resources semantically related to the MOOC resources that the learner had learned can be regarded as the learner's interest ontology.

5 Personalized recommendation of MOOC resources based on semantic association and user characteristics

The concept was an important component of the knowledge unit. By using a semantic association algorithm to calculate the correlation between concepts, we can get the correlation of knowledge and realize the graphical presentation of knowledge (Liang, 2015). Based on the construction of MOOC resource ontology, MOOC resources were expressed by related concepts and hierarchical relationships among concepts. By analyzing the hierarchical correlation between concepts of different MOOC resources and the attribute correlation between concepts of different MOOC resources, we can get the correlation between concepts, and then get the correlation between MOOC resources (Liang, 2015). Based on the semantic analysis among resources, we combined the analysis of learners' characteristics to perform the calculation of learners' interest in MOOC resources. According to the calculated results, we ranked the recommended MOOC resources based on the degree of interest from high to low and then made personalized recommendations of MOOC resources.

5.1 Analyzing the semantic relevance of MOOC resources

Analyze the hierarchical correlation degree between MOOC resource semantics. The correlation degree between information was the correlation or contrast relationship between two groups of information, which can be realized by semantic correlation analysis of metadata between information (Gruber, 1993). The correlation degree between information can be analyzed from many angles, among which the hierarchical correlation degree (i.e., the hierarchical relationship between instances and their common ancestors) was a common analysis method. According to the literature (Li et al., 2015), The formula for calculating the hierarchical correlation degree was as follows:

$$SimHJA_{(x,y)} = \frac{defth(LCA)}{\max(defth(x), defth(y))} \tag{1}$$

In which, defth (LCA) denoted the depth of correlation between two ontological instances (i.e., the category intersects), the depth at which the category reached the ancestor node (i.e., the original node of the ontology), and Max (defth (x), def (y)) denoted the breadth of correlation (i.e., how many categories were divided on the hierarchy).

Taking two MOOC resource ontology examples I1 "Chinese Tea Culture" and I2 "New Media Literacy" in Figure 4 as examples, their hierarchical association was shown in Figure 5. And there were four hierarchical intersection paths between I1 and I2. From Fig. 5(a), the depth of correlation of the two instances was 2. From Fig. 5(b), the maximum depth of the intersection correlation branch of the two instances, that was the breadth of the two instances was 4. From the formula (1), the degree of hierarchical correlation between the two instances was:

$$SimHJA(I_1, I_2) = \frac{defth(LCA)}{\max(defth(I_1), defth(I_2))} = \frac{defth(LCA)}{\max(defth(C_{I1}), defth(C_{I2}))} = \frac{2}{4} = 0.5 \qquad (2)$$

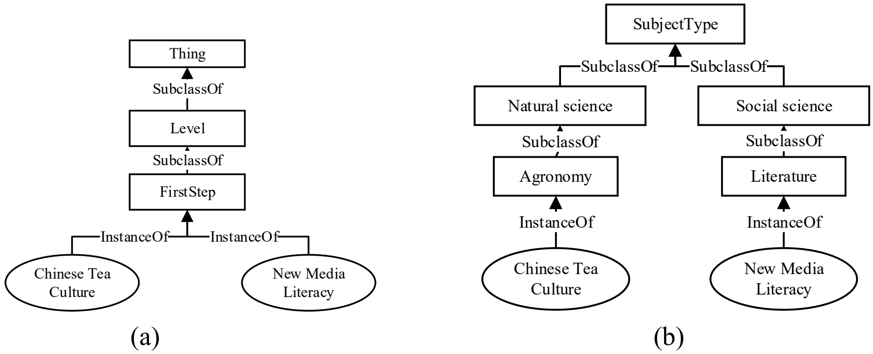

Fig. 5. Hierarchical intersection association between MOOC resource ontology instances I_1 and I_2.

Analyze the attribute correlation degree between MOOC resource semantics. Attribute association was the association between two instances due to the same or similar attributes (Gruber, 1993). By analyzing the attributes of things defined by learners, we can connect the attributes of things and get the relationship between the attributes of things. The method for calculating the degree of attribute association in two ontology examples in literature (Li et al., 2015) was as follows:

$$SimPJA(x, y) = \frac{1}{k} \cdot \sum_{i=1}^{n} \frac{1}{length(PJA_i)} \qquad (3)$$

In which, “k” represented the number of paths related to the attributes of two instances of x and y; Length (PJAi) indicated the depth of the branch under the same attribute where the instance was located.

Taking two MOOC resource ontology examples I1 "Chinese Tea Culture" and I2 "New Media Literacy" in Figure 4 as examples, their attribute association was shown in Figure 6. And there were four hierarchical intersection paths between I1 and I2. From the formula (1), the degree of attribute correlation between the two instances was:

$$SimPJA(I_1, I_2) = \frac{1}{4} \cdot \left(\frac{1}{length(PJA_1)} + \frac{1}{length(PJA_2)} + \frac{1}{length(PJA_3)} + \frac{1}{length(PJA_4)} \right) \qquad (4)$$

$$= \frac{1}{4}\left(\frac{1}{2} + \frac{1}{6} + \frac{1}{2} + \frac{1}{4}\right) = \frac{17}{48} = 0.35$$

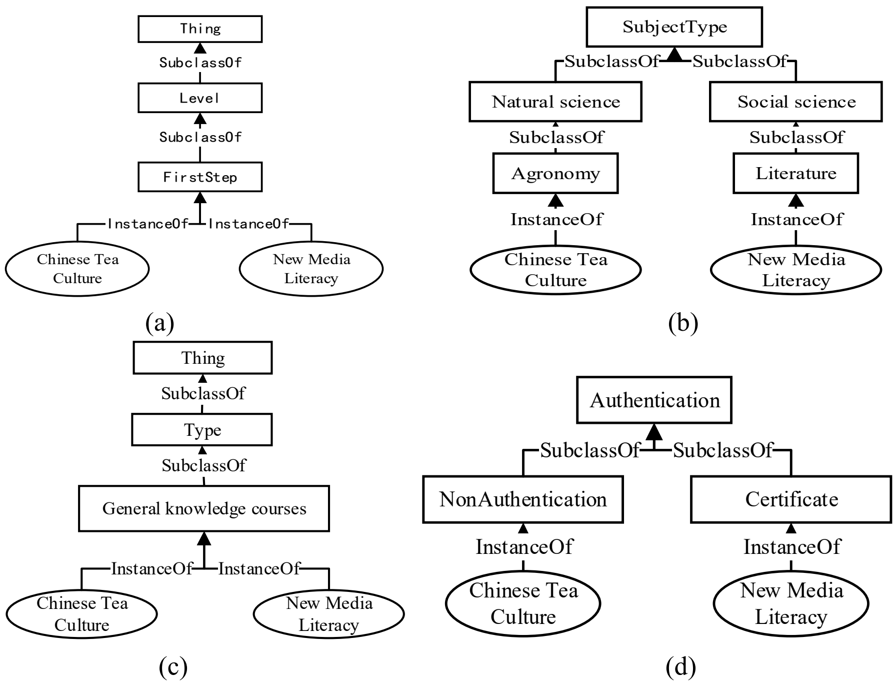

Fig. 6. Attribute intersection association between MOOC resource ontology instances I_1 and I_2.

Analyze the comprehensive semantic relevance of MOOC resources. Introducing weight was the key technology of effective and accurate classification in knowledge analysis in the era of big data (Shi et al., 2018), and weight can reflect the importance of each part in the whole. Different weights were given to the correlation degree of hierarchy and attribute, and the comprehensive semantic correlation degree can be obtained by comprehensively calculating the correlation degree of hierarchy and attribute. In this calculation of comprehensive semantic relevance, let the weight of hierarchical relevance be $\alpha(0\leq\alpha\leq1)$, the weight of attribute relevance be $\beta(0\leq\beta\leq1)$, and $\alpha+\beta=1$. Combining formula (1) and formula (3), the comprehensive semantic association degree between any two MOOC resource ontology instances was obtained, and the calculation formula was as follows (Shi et al., 2018):

$$SemSim_{(x,y)} = \alpha \cdot SimHJA_{(x,y)} + \beta \cdot SimPJA_{(x,y)} \tag{5}$$

In this study, the MOOC resource ontology model and learner ontology model was constructed, and the MOOC resources to be recommended and the MOOC resources learned by learners were modeled. By using comprehensive semantic correlation degree calculation based on hierarchical correlation degree calculation and attribute correlation degree calculation, this study analyzed the relationship between the MOOC resources that learners had learned and the resources to be recommended and obtained the learners' interest in the resources to be recommended. According to the calculated interest degree of learners to the MOOC resources in the resource library, the MOOC resources were sorted in the order from high-interest degree to low interest degree, and the sorting table was constructed, so that the MOOC resources with high-interest degree of learners were extracted to make personalized recommendations for learners.

According to the literature (Shi et al., 2018), the semantic similarity between the MOOC resources to be recommended and the learner's interest ontology can be calculated to predict the learner's interest in the MOOC resources, which can be used as a reference for a personalized recommendation of resources. The calculation formula was:

$$D(I_i) = SemSim(I_i, UserOnto) = \sum_{j=1}^{n} SemSim(I_i, I_j) \cdot D(I_j) \tag{6}$$

5.2 Personalized recommendation of MOOC resources combined with learners' characteristics

A MOOC resource based on semantic relevance similarity cannot judge the interest and preference of the first-time learners or other non-graded learners and had the problem of cold-start. Based on this, this study considered the combination of learner information in learner ontology, the characteristics and needs of different learners, and the combination of semantic similarity for a comprehensive recommendation.

There are many factors that affect MOOC learners' learning, including learners' gender, age, region, frequency of internet connection, learning background, degree, religious belief, whether they have MOOC experience, and so on (Zhan, Huo, Yao & Dai, 2019). In learner information, the learner's occupation can indicate the need of the current stage, such as the study of the subject knowledge that the student needs, the guidance of the examination; Housewives can use MOOC resources to teach general knowledge to learn new knowledge, develop hobbies, etc. The characteristics of learners' age reflect the learners' knowledge accumulation and cognitive level to some extent. For example, younger learners with less accumulated knowledge and lower cognitive abilities might consider recommending entry-level MOOC resources first; for older learners, MOOC courses that teach general knowledge, rather than exams and training courses, could be prioritized to meet learners' lower levels of acceptance and interest preferences. And the learners' hobbies also largely implied the learners' preferences for different courses. By combining the characteristics of learners in learner ontology (age, occupation, hobby, etc.), we got the recommended list LH, and then calculated the recommended list LS based on semantic similarity, in order to obtain the final result of interest calculation, different weights A and B ($a + b = 1$, $a >= 0$, $b >= 0$) were assigned to the result of interest calculation based on the characteristics of learners and the result of Semantic Association analysis, to get a list of personalized recommendations for the course, LM calculated the following:

$$L_m(I_i) = a \cdot L_h(I_i) + b \cdot L_s(I_i) \tag{7}$$

6 Simulation case of personalized recommendation and analysis of recommendation effect

6.1 Simulation case design

In the simulation case, based on the construction of learner ontology, we designed the learner named “Li Lei”. The experiment chose three popular MOOC courses, MOOC, MOOC Net, and Superstar MOOC, as examples to analyze the MOOC resource ontology. We used the above-mentioned personalized recommended path of MOOC resources to recommend “Li Lei” MOOC resources, and analyzed the effectiveness of the recommendation, in order to verify whether the personalized recommendation method of MOOC resources in this study.

Based on the above idea of constructing the learner ontology model, we constructed Li Lei’s learner model. We assumed that Li Lei is an 18-year-old college freshman majoring in computer information technology who enjoyed computer programming and playing games, so the basic information model for Li Lei’s learners was: Userinfo = {“123964578@qq. com”, “Li Lei”, “Male”, 18, “Undergraduate”, computer information technology, freshman, computer programming, games}. Let's assume that the learner Li Lei had finished two courses, I3 "University Computer Foundation", and his interest in this course was 0.8 points (1 is out of full marks); I4 "Wisdom of Chinese Studies", the interest degree was 0.3 points (1 is out of full marks), and the historical information model of learners was: UserHis= {(I3, 0.8), (I4, 0.3)}. Based on the learning history of learners, we took the MOOC resources that learners have learned as the set of MOOC resources that learners may be interested in. The analysis of Li Lei's UserInter was shown in Figure 7:

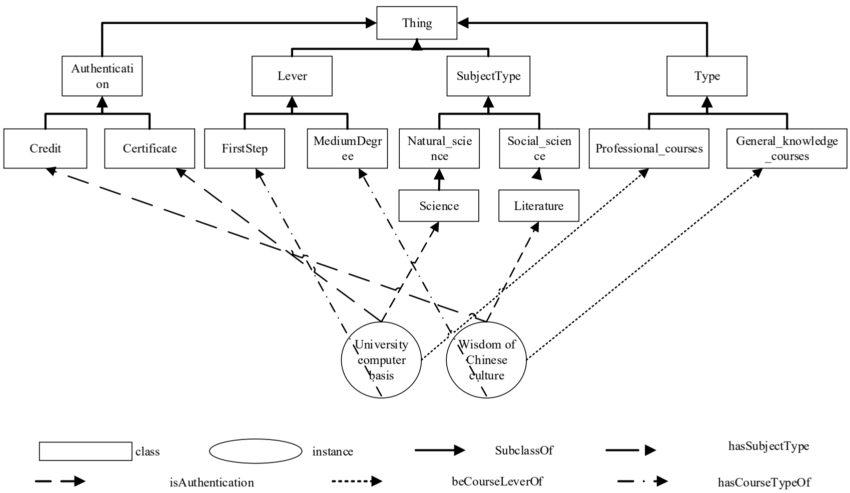

Fig. 7. UserInter of Learners

6.2 Personalized recommendations for MOOC resources

According to Li Lei's learner model, we used semantic association analysis to recommend resources individually. At first, semantic diffusion was carried out on the MOOC resources in UserInter that learners were interested in and examples with semantic correlation with examples I3 and I4 were found in MOOC, MOOC Net, and Superstar MOOC. In order to facilitate research and analysis, we randomly selected 10 examples from a large number of obtained examples for analysis and obtained the possible favorite MOOC resource set of Li Lei, i.e., the resource set to be recommended, which was: I = {(I5, "Introduction to Java Concurrent Programming and High Concurrent Interview"), (I6, "All-round in-depth Analysis of Vue.js_ Source Code"), (I7, "Information Retrieval"), (I8, "Zhang Yu Mathematics Advanced Mathematics Enhancement"), (I9, "Fashion and Brand"),(I10, "Educational Research Methods"), (I11, "Ten Lectures in Ming History"), (I12, "University Computer-The Road to Computational Thinking"), (I13, "Globalization and World Politics Research"), (I14, "children dance and Learning")}.

According to the formulas (5.1), (5.2), and (5.3), We calculated the semantic association degree between the MOOC resources to be recommended and the MOOC resources I3 and I4 that the learner was interested in. In formula (5.3), α=0.5, β=0.5. The calculated results were shown in Table 1.

Table 1. The semantic relevance between the recommended MOOC resources and the MOOC resources I3 and I4 that learners are interested in.

MOOC resources ID	Semantic relevance with I_3			Semantic relevance with I_4		
	hierarchical correlation degree	attribute correlation degree	Comprehensive semantic correlation degree	hierarchical correlation degree	attribute correlation degree	Comprehensive semantic correlation degree
I_5	1	0.38	0.69	0.25	0.23	0.24
I_6	1	0.31	0.66	0.25	0.23	0.24
I_7	1	0.38	0.69	1	0.38	0.69
I_8	1	0.31	0.66	0.25	0.22	0.23
I_9	0.5	0.35	0.43	1	0.38	0.69
I_{10}	0.5	0.42	0.46	0.67	0.25	0.41
I_{11}	0.25	0.29	0.27	0.67	0.35	0.46
I_{12}	1.5	0.5	1	0.25	0.23	0.24
I_{13}	0.5	0.42	0.46	0.67	0.25	0.41
I_{14}	0.5	0.35	0.43	1	0.31	0.66

According to table 1, we got the semantic relevance between the MOOC resources to be recommended and the MOOC resources I3 and I4 that the learner was interested in, and calculated the product of the relevance between the MOOC resources and the resources that the learner was interested in by formula (5.6), so as to get the score prediction that the learner may give to the MOOC resources. The interest degrees of the learners to the diffusion examples were as follows: UserInter(I5) =0.62, UserInter(I6) =0.6, UserInter(I7) =0.76, UserInter(I8) =0.6, UserInter(I9) =0.55, UserInter(I10) =0.49, UserInter(I11) =0.35, UserInter(I12) =0.87, UserInter(I13) =0.49, UserInter(I14) =0.54. According to sorting the MOOC resources to be recommended from high to low according to the prediction score, the recommended list Ls was as follows: Ls={(1,I12),(2,I7),(3,I5),(4,I6),(4,I8)(5,I9)(6,I14)(7,I10)(7,I13)(10,I11)}.

Because different platforms and learners had different specific situations, the richness of learners' information was different. In order to facilitate the classification, this section took professional information in learners' information as an example for analysis. We divided occupations into four most common categories: "students", "company employees", "freelancers" and "unemployed". The curriculum types in MOOC resources were closely related to learners' professional information, so we analyzed the curriculum types of MOOC resources according to learners' professional characteristics, so as to get the recommended list of MOOC resources based on learners' information. Among them, if the learner's occupation was "student", the ranking of the MOOC resource recommendation list was: Professional courses, Exam courses, General knowledge courses, Skill training courses ; if the learner's occupation was "company employees" and "unemployed", the ranking of the MOOC resource recommendation list was: Skill training courses, Exam courses, General knowledge courses, Professional courses ; if the learner's occupation was "freelancers", the ranking of the MOOC resource recommendation list was: General knowledge course, Exam courses, Skill training courses, Professional courses.

Combining the semantic correlation analysis between resources and learner characteristics analysis, the ranking of each MOOC resource to be recommended in the recommendation list based on semantic similarity analysis and the recommendation list based on learner information was obtained. We set the weight of these two ranking values to 0.5, add these two values, and finally sort the ranking values from small to large, which was the ranking of the MOOC resource to be recommended in the recommendation list. The ranking of course resources in Li Lei's list of MOOC resources to be recommended as shown in Table 2 below. Among them, the smaller the ranking value, the higher the ranking, the more likely it was to be recommended.

Table 2. Recommended ranking of MOOC resources to be recommended.

MOOC resources ID	Recommendation list L_s based on semantic association analysis	Recommendation list L_b based on learner information analysis	Comprehensive recommendation list L_m
I_5	3	4	3
I_6	4	4	4
I_7	2	4	2
I_8	5	2	3
I_9	6	3	5
I_{10}	8	1	5
I_{11}	10	3	7
I_{12}	1	1	1
I_{13}	9	1	6
I_{14}	7	1	4

6.3 Recommendation effect analysis

Li Lei, as an undergraduate majoring in computer science, was more interested in "University Computer Foundation" than "Wisdom of Chinese Studies". In the recommended list of this study, it was predicted that Li Lei was interested in the courses of "University Computer-the Road to Computational Thinking", "Information

Retrieval", "Introduction to Java Concurrent Programming and High Concurrent Interview", which were related to science and engineering and computer, and were consistent with the actual interests and professional situations of learners. However, for courses with strong professionalism such as "Teaching and Learning in children dance" and "Ten Lectures on Ming History", which were far from the actual situation of learners, the recommended ranking calculated by the recommendation system was also lower. Personalized recommendation of MOOC resources based on semantic correlation analysis between resources and learner characteristics analysis can achieve the effect of personalized recommendation of courses to learners in many MOOC resources and can improve the efficiency and applicability of course selection for learners.

In the simulation recommendation case, through the analysis of the semantic correlation between resources, two courses with different concepts but related concepts were connected, which solved the problem that the recommended resources were too close to the referenced interest resources in the ordinary recommendation process, resulting in the recommendation result being too single. Combining with the basic information of learners (taking occupation as an example), the recommendation analysis not only solved the problem of recommendation cold start but also made the recommendation closer to the learner's own role.

7 Conclusion

Based on the calculation of hierarchical relevance and attribute relevance among MOOC resources, the ranking table of resources to be recommended based on semantic relevance analysis was obtained. Combining with the occupation categories in the basic information of learners, the ranking table of resources to be recommended based on the analysis of the basic information of learners was obtained. A comprehensive analysis of the above two resource ranking tables can predict learners' interest in these resources and get the final ranking table of resources to be recommended, which can be used as a reference for the personalized recommendation of MOOC resources. The learning resources and learner ontology constructed in this study can provide theoretical references for related research. Through semantic association analysis, the study found the courses that were semantically related to the courses that learners were interested in, realized the diffusion search of resources, and solved the problem that the recommendation results were too single in the process of personalized recommendation of resources. By analyzing the basic information of learners, the problem of cold start in the process of personalized resource recommendation was solved. In this study, a simulation case was used to explain the personalized recommendation method of MOOC resources. In the actual application process, based on this MOOC resource personalized recommendation idea, we can further consider more basic information of learners in the process of personalized recommendation analysis and continuously optimize the recommendation results. This study mainly provided an idea of personalized recommendation of learning resources. Under this idea, researchers can further deepen the analysis and find more possibilities to realize personalized recommendations of learning resources.

Learning resources and the construction of learner ontology need to be improved with the introduction of new technologies and the change of user habits. Combining existing methods to improve the accuracy of recommendation in mixed recommendation was our further research content. In the following research, we can improve it from the following aspects: (1) we can refer to more experts' opinions to build a more scientific and comprehensive learning resource and universal ontology that can adapt to the development of learners; In this study, the weights of hierarchical correlation and attribute correlation in semantic association, as well as the weights of user characteristics and semantic association characteristics were not analyzed in detail. In the following study, the weights in recommendation can be further analyzed according to the specific recommendation situation to improve the accuracy of personalized recommendation of resources. At present, this study only analyzed and recommends users' professional characteristics. In the following study, users' characteristics in multiple dimensions, such as interests and ages, can be comprehensively analyzed, so as to optimize the personalization of recommendations.

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Design for Blended Learning in Distance Education via the Moodle Platform

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Abstract
Purpose – The The Open University of China (OUC) started to implement blended learning (BL) in distance education based on the Moodle platform in 2013. However, according to the researchers' ongoing observations since then, the current practice of BL at the OUC involves either 'more face-to-face (F2F), less online' or 'F2F equal to online', both of which are heavily dependent on the traditional knowledge transfer from teachers to learners. In this context, it will be of significance to investigate the learners' experience in the practice of BL; explore the pedagogy suitable for the distance learners at the OUC; and discuss how to concretely design for and implement BL courses via the Moodle platform so as to carry out a more mature and effective BL mode.
Methodology – This study was carried out at Nanhai Experimental College in the OUC through employing *A Survey on the Learners' Experience in the Practice of BL*. The questionnaire was published on the website www.wjx.cn (a popular platform for online surveys in China) to collect anonymously the relevant information from distance learners at the end of the autumn semester of 2019. It was administered for two weeks, and 257 valid responses were received.
Findings – The survey of learners' experience of participating in the current BL modes deployed at the OUC shows that tutors need to pay attention to the diversity of learning approaches, the autonomy of learning habits, and the innovation of learning tasks when designing for BL courses.
Implications – The BL pedagogy suitable for distance education should be directed by contemporary learning theories, committed to engaging learners in a dynamic learning process and guiding them to autonomously construct new knowledge based on the online learning materials and activities, so as to leave F2F tutorials for in-depth discussion between the tutor and the learners on key issues to realize the assimilation of knowledge. Gradually, the mode of 'more F2F, less online' should be abandoned to adopt that of 'more online, less F2F'.

Keywords: distance education at the OUC; contemporary learning theories; design for blended learning

1 Introduction

As was stated in *EDUCAUSE Horizon Report: 2019 Higher Education Edition* "Blended learning (BL) designs have steadily increased as a favored course delivery model alongside fully online options…[however] the challenges of scaling this modality persist for some institutions"(p.12). BL designs taking full advantage of digital platforms and incorporating more innovative pedagogical approaches would be an important trend driving educational technology adoption in higher education in order to support the growth of BL.

As for the definition of BL, different scholars have different ideas based on different perspectives. Picciano *et al*. (2014) classified various definitions into two categories: one focuses on surface features (physical structuring) of BL systems, such as "a portion of face-to-face (F2F) time is replaced by online activity", the other on the pedagogical structuring, such as "[in order to] reach a variety of student and learning needs, [BL design should] consider six pedagogical objectives: content, student social and emotional support, dialectic/questioning activities, reflection, collaboration and synthesis/evaluation/assessment"(p.25-30). Li and Zhao (2004) also stated that superficially BL is a blend of online and F2F learning, but essentially it involves a blend of learning modes based on different theories, a blend of activities led by the teacher and those centered on learners, a blend of learning environments for physical classroom and those for virtual learning and a blend of various delivery media, etc. Therefore, it is necessary to clarify that rather than just a hybrid of F2F and online learning approaches, BL is basically a blend of pedagogy and learning technologies based on different learning theories, for the purpose of achieving optimal learning outcomes.

The Open University of China (OUC) started to transfer its online learning to the Moodle platform in 2013 and gradually promoted the BL modality via this new platform and thus commenced a new era of BL for distance education in the whole OUC system. However, according to the researchers' ongoing observations from then on, the current practice of BL at the OUC is either "more F2F, less online" or "F2F equal to online", both heavily depending on the traditional knowledge transfer from teachers to learners, lacking scientific integration of online with F2F, uploading tediously long textual online learning resources, paying inadequate attention to the design of interactive online learning activities, and failing to effectively guide distance learners to actively participate in online learning. (Zhong, 2016; 2017) In this context, it will be of significance to investigate the learners' experience in the practice of BL, and to explore the pedagogy suitable for the distance learners at the OUC and discuss how to concretely design for and implement BL courses via the Moodle platform so as to carry out a more mature and effective BL mode.

2 Methodology

This study was carried out at Nanhai Experimental College of the OUC (NHOUC) through *a Survey on the Learners' Experience in the Practice of BL*. The questionnaire was published on the website www.wjx.cn (a popular platform for online survey in China) to anonymously collect the relevant information from distance learners at the end of the autumn semester of 2019, which was administered for two weeks and 257 valid samples were received.

Among the 257 learners surveyed, about 63% were females and 79% were humanities majors. According to the information collected from the teaching department of the NHOUC, the gender ratio and profession ratio of the samples are roughly in line with the current demographic distribution of the 8000 enrolled learners in the autumn semester of 2019, hence to certain extent the samples are representative.

The questions in the questionnaire elicited socio-demographic data (gender, age, profession category, etc.), experience in the practice of BL and suggestions about how to improve BL. 18 closed and 2 open-ended questions were included, with the former focused on experience and the latter on suggestions.

The data of the questionnaire were imported into SPSS and EXCEL software for statistical analysis and the project's findings were derived.

3 Results

In terms of ages, 218 respondents were under 30 (including 30 years old, the same below) while only 39 over 30, with the youngest being 16 years old and the oldest 51 years old, which indicates that the learners of the NHOUC are young in general, but with a wide span of ages.

3.1 Analyses of Learners' Experience

As for the answers to the question "What's your chief way to study the subjects in the curriculum?", a pivot analysis (Table 1) was made between the different answers and the ages of the respondents, which demonstrated that almost the same amount of respondents single-opted for "taking F2F classes" and "studying on Moodle platform" ; Much more respondents double-opted for "studying on Moodle platform" + "taking F2F classes" than "studying on Moodle platform" + "self-studying textbooks", with the latter actually being the least number of all; The number of respondents who opted for all the three learning approaches was the largest; The respondents who single-opted for "self-studying textbooks" were all under 30 years old.

The above findings have reminded the tutors that: 1) learners accept BL approaches and recognize that online learning is almost as important as F2F; 2) learners have traditionally high expectations for F2F learning but low for pure online learning and self-study; 3) Some young learners prefer autonomous learning by way of self-studying textbooks.

Table 1. A pivot table report between the learning approaches and the ages of the respondents.

Count	What's your chief way to study the subjects in the curriculum?							
Age group	Taking F2F classes	Studying on Moodle platform	Taking F2F classes+ self-studying textbooks	Studying on Moodle platform + taking F2F classes	Studying on Moodle platform + self-studying textbooks	Self-studying textbooks	Studying on Moodle platform + taking F2F classes+ self-studying textbooks	Total
Under 30 years old	33	32	14	55	10	16	58	218
Over 30 years old	5	5	1	12	2	0	14	39
Total	38	37	15	67	12	16	72	257

Notes: The question "what's your chief way to study the subjects in the curriculum?" is a MCQs and the respondents may choose one or more than one options.

When answering the open-ended question at the end of the questionnaire, some learners specifically pointed out that "it's unfair for tutors to lower my participation grade when I don't come for the F2F classes since I live far away from the campus", which reminded the tutors that when designing a formative assessment scheme they should not assign a large portion of marks to attending F2F classes and should offer the learners some other alternatives to make up for the marks that they cannot obtain from F2F.

As for the answers to the questions "What do you often do before/ after attending F2F classes?"(Table 2), about 67% of the respondents would "log in the Moodle platform to check if there are any tasks or assignments" before attending F2F classes, while about 78% of them would "always pay attention to teachers' notifications and complete online assignments on time" after F2F; 50% or so would "study on Moodle platform" or "preview/review textbooks" both before and after F2F classes; however, more than 10% would "have little time for preview/review" before or after F2F. These findings have reminded the tutors that: 1) As long as the learning design would scientifically guide learners to autonomously study the online resources and textbooks, the traditional knowledge transfer process could be done by learners themselves since most of them attach importance to preview/review and online assignments; 2) a few learners couldn't take care of the autonomous study tasks before or after F2F and hence need more attention and intervention from the tutors.

Table 2. What do you often do before/ after attending F2F classes?

Options	Before F2F (proportion)	After F2F (proportion)
Log in the Moodle platform to check if there are any tasks or assignments	66.54%	78.21%
Study on Moodle platform	51.75%	57.98%
Preview/review textbooks	52.92%	42.02%
Have little time for preview/review	15.95%	11%

Notes: The questions "what do you often do before attending F2F classes?" and "what do you often do after attending F2F classes?"are both MCQs and the respondents may choose one or more than one options.

As for the answers to the question "How do you treat the forums on the Moodle platform?", about 29% of the respondents stated that they "occasionally copy (others' comments) and paste", about 3% said that they "always copy and paste", but up to about 65% believed that they "really think and write down their own views". These findings have reminded the tutors to take necessary measures to ensure the quality of forums, including posting topics and themes that really motivate the learners to think deeply, facilitating the discussions effectively, intervening the phenomenon of copy and paste in time and urging all learners to form a habit of writing down their authentic views. Besides, about 3% of the respondents said that they "hardly participate in any forums", and these students are the so called "quiet students" (OU, 2009, p. 22) who require extra proactive support from their tutors in case any of them would drop out.

As for the answers to the question "How do you treat the assessment tasks on the Moodle platform?", about 80% of the respondents chose the option "from the beginning of the semester, I will do the tasks one by one according to the assessment scheme published on the platform"; however, about 19% chose the option "I have no time to take care of the tasks until the end of the semester", which reminds the tutors to scientifically design the assessment scheme and effectively use assessment and feedback as critical drivers in guiding the learners to evenly distribute their effort and energy in the study.(Salmon, 2011)

As for the answers to the question "What types of assessment tasks can scientifically assess your understanding of relevant knowledge?", a pivot analysis (Table 3) was made between the different answers and profession categories of the respondents, which demonstrated that, on the whole, a larger proportion of respondents single-opted for "objective questions (OQs, those with standardized answers, e.g. MCQs and True or False questions)" and triple-opted for "objective questions" + "subjective questions (SQs, those with flexible answers, e.g. case analyses) " + "open-ended discussions (OEDs)"; but the tasks recognized by the learners vary with their profession categories, that is, larger proportions of science majors single-opted for "OQs" and double-opted for "OQs" + "OEDs" while similarly larger proportions of humanities single-opted for "OEDs" and triple-opted for "OQs" + "SQs" + "OEDs". These findings have reminded the tutors that: 1) OQs are a form of widely-accepted tasks; 2) neither single-option for "SQs" nor double-option for "SQs" + "OEDs" is widely-accepted by science majors or humanities; 3) they must try to diversify the assessment tasks to evaluate the learners' performance in a more innovative and creative way, e.g. SQs presented in the forms of OQs or OEDs to stimulate the learners' higher-order thinking.

Table 3. A pivot table report between the types of assessment tasks and profession categories of the respondents.

Count	What types of assessment tasks can scientifically assess your understanding of relevant knowledge?						
Profession	OEDs	OQs	OQs +OEDs	OQs+SQs	OQs+SQs +OEDs	SQs	SQs+OEDs	Total
Science	5/ 9.43%	21/ 39.62%	7/ 13.21%	9/ 16.98%	5/ 9.43%	4/ 7.55%	2/ 3.8%	53/ 100%
Humanities	30/ 14.71%	59/ 28.92%	17/ 8.33%	33/ 16.18%	41/ 20.10%	17/ 8.33%	7/ 3.43%	204/ 100%
Total	35/ 13.62%	80/ 31.13%	24/ 9.34%	42/ 16.34%	46/ 17.90%	21/ 8.17%	9/ 3.50%	257/ 100%

Notes: 1.The question "What types of assessment tasks can scientifically assess your understanding of relevant knowledge?" is a MCQs and the respondents may choose one or more than one options.

2.The percentage after each number in the table is the ratio of that number to the total in the same row.

3.2 Some Hints Based on Learners' Experience

Based on the above analyses of learners' experience, the tutors must take the following three points into account when designing for BL:

1) Diversity of learning approaches. The chief way to study the subjects in the curriculum varies with the learners' ages hence the BL design must offer learners some alternatives of learning approaches to choose from instead of a uniform one.

2) Autonomy of learning habits. Since most learners would take care of the online learning tasks before and after F2F, they could be guided by a scientifically- designed learning scheme to autonomously construct new knowledge through online learning so as to leave F2F tutorials to in-depth discussion between the tutor and the learners on key issues to realize the assimilation of knowledge.

3) Innovation of assessment tasks. In addition to presenting SQs in the forms of OQs or OEDs, tutors must create various authentic tasks related to adult learners' rich social and working experience so that learners might be more interested in and engaged with the assignments. Just as Bonk and Khoo (2016) asserted that, in today's sociocultural learning era, teachers should consider how to make learning relevant, authentic and meaningful when designing for learning.

4 Pedagogy for BL Courses at The OUC

The term pedagogy comes from the Greek words *paid* (child) and *agogus* (leader of), which directly translated means *to lead the child*. (McGee, 2014, p.35) The authors believe that in the context of BL, pedagogy refers to the design for what learners do in F2F as well as online learning and the scientific hybrid of these two learning approaches in order to facilitate learning. Different pedagogy might be guided by different learning theories.

Psychologists have put forward quite a few learning theories based on different viewpoints concerning what it takes to learn in formal education and derived from different experimental data. Laurillard (2012) listed and explained 8 learning theories, including behaviorism, associative learning, cognitive learning, experiential learning, social constructivism, conceptual learning, constructionism and collaborative learning. She proposed that each learning theory offers a different kind of insight into what it takes to learn so people should treat the contrasting theories as complementary and synergistic rather than oppositional. Bonk and Khoo (2016) also believed that each learning theory typically reflected the issue of human motivation to learn from different standpoints. They further illustrated four major learning theories through examples of learning activities, i.e., 1) behaviorists generally believe in scientific and objective measures of behavior to provide plausible explanations of learning so they advocate using external rewards and punishments to get the learners motivated. The tutors embracing behaviorism often set the computer-scored OQs to test the individual learner's understanding and give feedback quickly; 2) cognitivists believe that learners learn through perception and they are active seekers and processors of information, able to attend to, code, select, transform, rehearse, store, and retrieve information. Tutors embracing cognitivism often arrange OEDs to motivationally engage the learners in elaborating on their arguments or problem solutions; 3) constructivists believe that learners will actively participate in learning rather than passively accepting the knowledge transmitted by teachers and learning occurs best in problem-based settings where learners are required to use their prior knowledge and experiences to explore, inquire, interpret, reflect upon, judge, and construct understandings for themselves. Tutors who embrace constructivism are more likely to arrange debates, Wiki, fieldwork, project design, etc. to facilitate learner interaction and active exploration of course materials; and 4) sociocultural theorists believe that learners learn by participating in commonly valued activities of a particular group where cultural tools such as language and artifacts help learners understand each other and make meaning in a highly collaborative learning process. Tutors who advocate sociocultural theory tend to assign workshop, Wiki, fieldwork, blog posting, authentic learning tasks and so on to promote a supportive community of inquiry or learning community.

Although the functions of Moodle platform are mainly based on the educational framework of social constructivism, and He (2002) also held that constructivism was innately suitable for learning powered by information technology, Li and Zhao (2004) and Oliver (2005) argued that one of the components of BL was a blend of different theories and hence constructivism would not exclusively guide the pedagogy for BL courses. In reality, how to design for a BL course is affected by such factors as the nature of the course, the learning outcomes, the characteristics of learners, the teaching experience and style of tutors and online learning resources (Dziuban *et al.*, 2004). Lv (2015) suggested that, in the context of distance learning at the OUC, we should pay particular attention to the characteristics and learning habits of the learners and not implicitly set the assumption that learners have the ability to actively construct new knowledge when designing for BL. Therefore, the researchers of this study hold the view that the learning theories suitable for guiding the pedagogy for BL courses at the OUC include but not limited to constructivism.

Next, based on the analyses of the learners' experience and guided by constructivism and sociocultural theory, the researchers are to discuss how to concretely design for and implement BL course *preschool education policy and regulations* via the Moodle platform.

5 A Case Study of BL Course Design Via The Moodle Platform

5.1 Background of The Course

Preschool education policy and regulations is an optional course for the preschool education majors at the OUC. The intended learning outcomes include understanding the basic policies and regulations and demonstrating them to address the problems occurring in the current practice of preschool organizations as well as developing an awareness of law-based governance in education.

Adopting the mode of "more online, less F2F" and guided by constructivism and sociocultural theory, the design for this BL course requires the learners to autonomously complete the knowledge transmission process mainly through self-studying the textbooks and online learning materials as well as participating in online activities, so as to leave F2F tutorials to in-depth discussion between the teacher and the learners on key issues to realize the assimilation of knowledge.

5.2 Design for Assessment Scheme

The formative assessment accounts for 70% of the course mark, including workshop, forum and blog on the Moodle platform and performance in F2F classes (those who cannot take the F2F classes may watch recommended short videos online instead); the summative accounts for 30%, the learners are required to submit an essay of about 2,000 words to demonstrate the potential application of what they have learned into their practical work or life (Table 4). On the whole, the assessment scheme takes into account the diversity of learning approaches, the autonomy of learning habits and the innovation of assessment tasks.

Table 4. Assessment scheme for BL course *preschool education policy and regulations*

Assessment	Items		Weight(%)	Specifications
Formative	Moodle platform	Workshop	25%	write down your authentic views.
		Forum	15%	
		Blog	15%	Contribute two postings, 300 words each, and comment on at least one fellow participant's contributions.
	F2F/ Moodle platform	Attending F2F classes/watching short videos online	15%	No less than 3 times of attendance and performance in F2F, or watch 20 short videos online instead.
Summative	Moodle platform	An essay	30%	1)Your focus for the essay can be negotiated in consultation with your tutor. 2)The word length is around 2,000 words, consisting of introduction, body and conclusion. 3) It's not necessarily of academic value but you need to demonstrate how you apply what you have learned into your practical work or life.

5.3 Design for F2F Interaction

To implement the mode of "more online, less F2F", a week before F2F, the tutor uploads short videos, narrated slides and short chunks of text onto the Moodle platform for learners to learn autonomously and at the same time think about the topics on "the list for F2F discussions" which is also posted online in advance; in the process of F2F, the tutor usually does not have didactic teaching but organize group discussions based on the list, or, for some key concepts, learners try to relate them to the context of their practical work or life and express the meanings in their own words, with the group representative's or individual learner's performance being evaluated by both the tutor and learners. Therefore, in the interactive F2F classes, the tutor plays a role of moderator instead of a traditional expert.

5.4 Design for Online Interaction

If the virtual learning environment (VLE), even with much use of learning technologies, offers online learning in a way that relies mainly on knowledge transmission rather than construction, both the learners and teachers will experience banality, confusion and even disappointment (Salmon, 2005, p.206). In view of this, the design for the online part of the course focuses on facilitating the interaction between learners and peers, learners and teachers, as well as learners and contents to help them construct knowledge independently. Before F2F, the initial interaction between learners and contents occurs when learners are guided by "the list for F2F discussions" to read the recommended online materials and/or some part of the textbook; after F2F, three types of online interactive learning activities are arranged by turns:

Type 1: workshop. This activity is designed to train learners to analyze and evaluate the knowledge they have learned. The tutor sets in advance the points for collecting comments so as to guide learners to comment on the assignment of their peers. Each assignment is reviewed by two peers. What the learners benefit from this activity is that they will gradually construct a clearer concept by analyzing and evaluating their peers' assignment and be motivated for further study by reading the comments from their peers and the summary feedback from the tutor.

Type 2: forum. This activity is designed to train learners to analyze and apply the knowledge they have learned. Two asynchronous discussion boards are arranged, the learners may choose either or both to participate in. One is led by the tutor and must be completed in 4 weeks, where the tutor posts a topic thread, to which the learners may reply or just comment on the replies of their peers; the other is led by the learners themselves and open to contributions in the whole semester (as long as 18 weeks for a Chinese semester), where no topic thread from the tutor so learners can raise any questions related to the learning of the course and have diversified discussions with their peers and the tutor. No matter whether the discussion board is tutor-led or learner-led, its topic post must be of discussion value and the tutor needs to track the whole process, intervene at appropriate time and grade timely the participants' performance in order to facilitate continuous and deep discussions. In the process of participating in these OEDs, learners will actively seek, process, code and transform the relevant information and try to clearly express the concepts formed in their minds.

Type 3: blog. This activity is designed to train learners to think creatively. Due to the limited time, some key policies or regulations are not covered in F2F classes so the tutor makes some short videos and/or narrated slides and uploads them to the Moodle platform for learners to learn autonomously. After self-studying the online materials, the learners are required to write a blog post of about 300 words on how they extract relevant contents of a policy or regulation and apply them in the context of their own preschool education work. In these cases, their learning activities are made relevant, real and meaningful.

5.5 Design for Strategic Integration of F2F and Online

1) Since the beginning of the course, the assessment scheme worked as a critical driver of learners' learning and distributes learners' efforts evenly across topics and weeks (Salmon, 2011). Biggs (2003) suggested that the assessment should be constructively aligned with the intended learning outcomes and the teaching methods. To follow Salmon and Biggs, the tutor of this course presents the assessment scheme to learners in the first F2F class and at the same time uploads narrated slides on the assessment to the Moodle platform in order to make sure that learners understand how learning tasks are linked to learning goals and how they will be assessed. To complete each learning task, the learners need to think about the listed questions online before F2F, contribute to on site discussions at F2F and take care of other online interactive tasks after F2F. In a word, the assessment scheme step by step drives learners to complete various learning activities with quality.

2) "carrots" plus "sticks" motivate learners to actively participate in learning. Since this course does not have a traditional closed book proctored exam for the summative assessment, it is crucial for the tutor to empower learners actively participate in the learning process and complete each learning task with quality. Accordingly, the tutor adopts measures of "carrots" (encouragement) and "sticks" (penalties for not participating) to get learners involved in learning. (Salmon, 2011)

"Carrots" are the main measures. Some adult learners have suffered from blows in their previous studies, such as failing the college entrance examination or being unable to get rid of the shadow of "poor students", hence they particularly need feedback and encouragement from the tutor or peers to maintain their motivation for learning. For this reason, the questions for F2F discussions cannot be as easy as finding some specific contents from the textbook and reading them out, nor can they be so complicated that the learners need advanced professional background to make judgement or analysis, of which the balance lies in enabling the learners to gain and express some insights into their practical work or life. When the contents presented by a group representative meet the tutor's expectations, a sincere compliment will be immediately given to him or her and marks be recorded for all members of the group. At this time, the representative receives not only extrinsic marks, but also intrinsic self-recognition; when the contents are far from the tutor's expectations, the desirable points of the presentation should be focused on and praised, and then supplementary presentation from other members of the same group is encouraged so that the final version of points basically achieves learning objectives and all members of the group get the marks. In this collaborative learning process, the group members' self-efficacy has been developed. Besides, in order to perform better in the F2F discussions, learners log in the Moodle platform on their initiative to check "the list for F2F discussions" and preview relevant online resources or read particular part of the textbook before F2F so the interaction between learners and contents occurs and deep learning may be triggered.

"Sticks" are auxiliary. For those learners who fail to submit the formative assessment tasks twice, the tutor will take the initiative to contact them through mobile phone text messages or instant messaging tool such as QQ, informing them of the assessment scheme a second time and offering targeted support and help by understanding why the learners have failed to submit the assignments. However, the overdue assignments won't be offered a second opportunity to be submitted as a penalty. If the learners intend to pass the assessment of the course, they must complete the following learning tasks on time and with quality. Therefore, when the assessment scheme is strictly carried out by the tutor, it is a "stick" directly related to the successful completion of the course.

6 Conclusion

Based on the research environment of the NHOUC, the study has conducted a questionnaire survey to investigate the learning experience of learners in the implementation of BL via the Moodle platform, and explored, through the analyses of literature, the pedagogy suitable for BL at the OUC. Finally, taking the liberal arts course *preschool education policy and regulations* as an example, the study has discussed how to concretely design for blended learning under the guidance of contemporary learning theories.

Different learning theories should be treated as complementary and synergistic rather than oppositional and hence the pedagogy for a certain BL course can be guided by mixed theories instead of a single one.

Finally, the researchers of this study hope to make it clear that when designing for BL, what matters most is not the time proportion of F2F to online but the extent to which the pedagogy guides learners to be engaged in learning, autonomously construct new knowledge mainly through online learning resources and activities and thus gradually get rid of the current dependence on the knowledge transfer of F2F. For the distance learning at the OUC, the practice of "more F2F, less online" must be discarded while that of "more online, less F2F" will be the goal to pursue in the near future.

Notes

This paper is part of the outcomes of two research projects: One is Guangdong Province Open University (Guangdong Open Distance Education Research Fund) Research Project in 2019 "Design for and implementation of blended learning in distance education via the Moodle platform" (project approval No.YJ1912), the other is Guangdong Province Higher Education Teaching Reform Project in 2020 "Quality assuring system for MOOC-based flipped learning in distance education" (project approval No. 748).

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Transferring the Physical into Digital to Extend the Reach of Museum Access

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Abstract
Purpose – Opportunities exist for physical learning environments or spaces, such as museums, to provide online experience. Being online allows greater reach and exposure into rural, regional, interstate, and overseas locations to benefit from interacting and engaging with physical exhibits, or some of their artefacts, in a virtual environment. Advances in information technology (IT) can bridge gaps between physical and online spaces to support learning and knowledge acquisition irrespective of the learner's location. The online learning unit produced and presented in this paper complements a physical exhibit from a museum.
Design/methodology/approach – To envision the online learning unit, the physical museum and exhibit were reviewed and analysed to better understand the content, prominent themes, and the layout. The museum provides some online replicas of the physical artefacts, but not the complete experience. Reviewing the online material along with an examination of pre-existing online experience from museums helped to guide the design of the prototype to be tested. This work is focused on extending the reach of a physical museum exhibit. A mixed methods approach was taken in the heuristic evaluation for pre-user testing and evaluation, and participant testing.
Findings – Creating and testing the interactive online learning unit demonstrated the advantageous capabilities of using authentic artefacts to benefit learners unable to attend and engage in the physical museum. The complementary online and interactivity in the learning unit assists in creating a connection with learners who then engage with the experience. The design provided autonomy over individual learning needs or interests and, being experiential, also provided maximum impact. The use of web-related technologies facilitated and provided access and broadened the reach and appeal of the museum exhibit beyond the physical space and boundaries.
Originality/value/implications – Using available media with the intention of broadening the appeal, exposure, knowledge transfer and understanding directly benefits the learners while providing appropriate additional support and recognition for the role museums play in the community. The benefits for individual learners are evident, as is the potential for online learning units to be considered in educational settings in rural or regional areas where physical distance is problematic. Health and safety concerns encourage enhancing museums' efforts in digitizing aspects of their exhibits and adapting and incorporating these into intended and specialized learning units that benefit the museum and learners. Where feasible, maximum benefit is achievable from being physically inside the museum coupled with online learning units. If this arrangement is not possible, learners are not significantly disadvantaged given the incorporated content.

Keywords: online learning; museum education; online learning units; museum exhibits; learners; learner experience

1 Introduction

Understanding issues of immigration history is critical to understanding the multiculturalism, social inclusion and globalization in Australia (Encina & Santalucia, 2013). The Immigration Museum in Melbourne, Australia is uniquely placed to present histories, including those that are difficult, and to engage the public in reflecting current events with a broader social and political contexts and flows (Moya, 2010). It has consciously and purposefully inserted itself more firmly into community conversations about diversity, inclusivity, prejudice, and racism, and more importantly, it builds bridges between current learners and the past, promoting the social cohesion (McFadzean, 2012a; Witcomb, 2009). Like other immigration-themed museums, the museum uses various delivery method to address its educational purposes inside and outside the physical museum.

With the development of various digital platforms, people are now spending more time than ever on the Internet for formal and informal education. The internet and increased access to web-based resources can radically affect people and education, where technologies can now be more mobile, and learning can happen anytime, anywhere (Wishart & Triggs, 2010). The changes allow greater reach and exposure into rural, regional, interstate, and overseas locations to benefit from interacting and engaging with physical exhibits, or some of their artefacts, in a virtual environment. The transferring of the physical immigration-oriented museum learning into digital is not just provide some online replicas of the physical artefacts but complements physical exhibits and experience. Studies from Ho et al. (2011) and Lemmens and Vanstappen (2010) of museum virtual education found that museums online learning with activities through or based on museum physical learning experience should establish connections to individuals, their ideas and experience within a dynamic environment through active participant engagement. Holland (2019) said that using interaction to support knowledge construction and learner empowerment can deliver an effective museum online learning. The ideas of using interactivity and engagement to help museums deliver distant educational programs could be a useful and effective tool for immigration-themed museums to access learners beyond boundaries by clarifying how the ideas can complement the physical exhibits in immigration-oriented museums. Therefore, this study aims to examine the capabilities of online interactive learning for extending the reach of immigration-oriented/themed museum access into the digital areas. To address the purpose, two research questions are raised:

- *Research Question 1 (RQ1)*: how can digital content be used to transfer the physical exhibits into a digital form and offer the online learning experience to learners?
- *Research Question 2 (RQ2)*: what are learners' experiences and attitudes with accessing immigration-oriented museums through an online interactive learning unit?

2 Research Method

The section introduced the background of the cases study presented within the research, and the research method, including how the research was conducted, how the research recruited participants, and how the survey was designed.

2.1 Case Study Description and Method

This research project relates to online interactive learning for immigration-oriented museums, which primarily displays immigration history for the local region where the museum is located in. The lead researcher selected the "Getting In" exhibit in Immigration Museum Melbourne as the case study to investigate the use of online interactive learning unit in transferring the physical into digital, thus extending the reach of immigration-themed museums. "Getting In" focuses on the policies and processes of Australian immigration across time and it is an exhibition about selection and rejection, with content presented through text, statistics, graphics, objects and compelling interactives (McFadzean, 2012b).

The previous step of the research used the grounded design method, using branching narratives as an approach to design digital learning (Heussner, 2019; Wolff et al., 2007) to transfer physical learning experience in "Getting In" into online experience. Figure 1 displays the steps of the designed online interactive learning unit. There are four compulsory steps within the developed learning unit, which allowed learners to select an avatar as an applicant seeking migration to Australia by building their passport, selecting the, setting immigration journey, and exploring and a better understanding of life in Australia under the selected time. In addition, there is one optional step that offers the opportunity for learners to discover key features of immigration policies through explorations of word cards amongst different time periods.

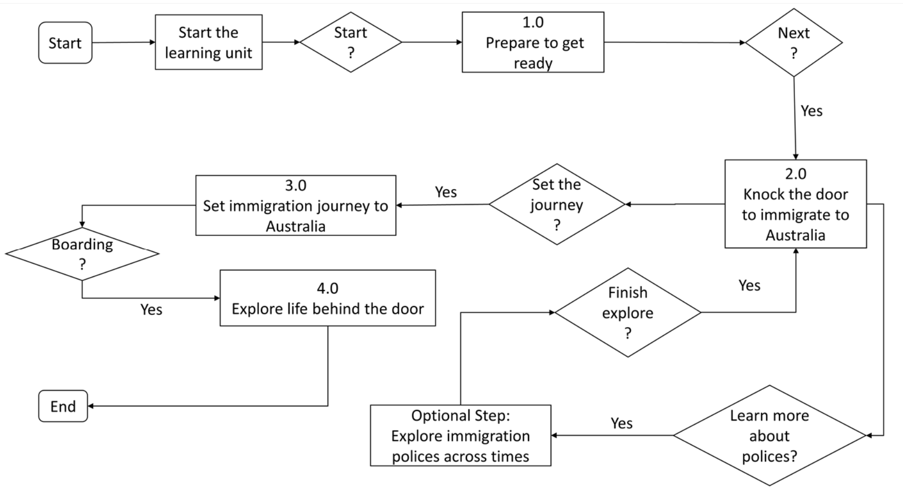

Figure 1 Processes flow diagram for the designed online interactive learning unit

The research utilized the developed working prototype to conduct an online anonymous survey to evaluate capabilities of the online interactive learning unit. Three steps were undertaken:

1. Survey release - designed and intended to collect data to assist in answering the research questions and to test the hypotheses.
2. Data collection - from participants in accordance with the approved ethics clearance.
3. Data analysis – of completed responses to test the proposed hypotheses and to address the research questions.

2.2 Participant Sample Size

For size of the sample, Nielsen (2006) summarized from 83 cases study related to the evaluation of user centered design, and found that most projects should stay with the tried-and-true, 5 users per usability test, and that 30 users can almost find all the problems. Based on this knowledge, the research project aimed to recruit 15-30 participants to maximize the benefit-cost ratio. The participants included 19 university students with adequate online learning experience and knowledge related to user centered design, hence these participants were capable to provide meaningful and informed feedback.

All participants were asked to respond to the online survey. Two steps were required:

- Exploration - participants explore the interface, interact with the working prototype, and investigate the online interactive learning unit.
- Assessment - participants assess the designed online interactive learning unit by completing the online anonymous survey.

2.3 Survey Design

In this study, the survey has been evaluated across three major domains, including 1) digital content, 2) usability principles, and 3) learning experience. The first and parts of the third domain was used to answer RQ1, and the second and parts of the third domain responded to RQ2. Each of the domains included both qualitative and quantitative questions. This mixed method was selected because, while collecting objective measures, it is also important to get users' perspectives on learning experience, to capture more individualized and detailed perceptions of the online learning unit (Nielsen & Pernice, 2010). The ratings scale in the questionnaire used a seven-point Likert Scale (1=Strong Disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, 7=Strongly Agree) simply because researchers found that people have more difficulty choosing a number in a five-point scale and that11-point scale offers too many choices, which takes people a long time to choose (Nielsen & Pernice, 2010).

Xie et al. (2018) said that digital content serves to deliver knowledge, information, and clear materials amongst online learning. The affordance and usefulness of content was considered as an important element of a virtual museums environment (Sylaiou et al., 2010). In the model for evaluating distance learning interactions, Daradoumis et al. (2006) summarized, that questions related content in digital interactions in self-evaluation questionnaire is an important source to analyze the quality of distance

interactive learning. Therefore, the quantitative questions of numerical rating and open questions were developed to evaluate the digital content in the designed interactive learning unit, to analyze whether and how digital content can transfer information from physical exhibits and can offer satisfied virtual learning experience.
Ten general principles for interaction design from Jakob Nielsen that are used as the broad rule of thumb and general usability guidelines for assessing design quality (Nielsen, 1994). Based on this grounded theory, the survey incorporated questions to evaluate the usability of the developed online interactive learning unit.
Weibel et al. (2012) stated that satisfaction of learners in virtual learning environment is important and is often referred to the success of the online learning. The attitude of learners on the developed digital interactive learning unit should be investigated, to find out whether and how learners think about the design. Therefore, quantitative questions were designed to collect helpful information about for users' learning experience. Additionally, questions related attitudinal data, such as people's thoughts, beliefs, and self-reported needs, were established to assess learners' attitudes towards virtual learning experience (Creswell & Clark, 2011).

3 Data Analysis and Results

The collected data was used to address both Research Questions (RQs). Firstly, the data was used test the research hypotheses, the results of which led to answering RQ1. Secondly, the data was analyzed to measure the usability of the online interactive learning unit and learners' general attitudes, thus addressing RQ2.

3.1 Hypotheses and the Approach to Test Hypotheses

Figure 2 outlined how to measure the strength of proposed hypotheses to address RQ1. The test started with the establishing of null hypotheses, H_{10} - H_{50}, which are there being no difference between different solutions or there being no correlation between two factors. Then, the alternative/opposite hypotheses were created, H_{11} - H_{51}. The research used statistical calculations to decide whether to reject null hypotheses at the Alpha significance level or not, where the Alpha significance is set as the default value, 0.05. H6 was analyzed through descriptive statistics and qualitative analyze of review comment. The analyzed outcomes were used to answer RQ1, how designed digital content in the in the online interactive learning unit imparts information related to physicals exhibits in immigration-oriented museums clearly and effectively to learners.

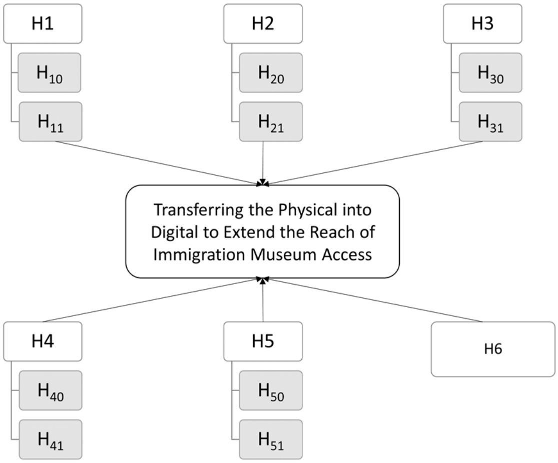

Figure 2 Hypothesis testing

Bangert (2004) concluded that digital learning content incorporating rich graphics and visual imagery with text were a better match for learners with visual processing strengths. With regards to cognitive load, the spatially close placement of corresponding text and pictorial information can reduce visual search and lower extraneous cognitive load, to increase learning experience (De Koning Björn et al., 2009; Mayer & Mayer, 2005). Lately, Ho et al. (2011) , found an overall high preference for still images with accompanying descriptive text. In the Immigration Museum Melbourne, the major compositions of "Getting In" exhibits are virtual items, such as pictures, images, and historical objects, aligned with text-based descriptions. Combining the past research results and the content in the physical museum. The research proposed that:

- *Hypothesis 1 (H1):* comparing to using text or graphics only to display information, the integration of these two types of digital content is more helpful and useful to assist learners in understanding information in the immigration-oriented online learning unit.

Normally, learning and exploration in physical museums is characterized as informal and free-choice, where learners have chances to jump between items and learners are free to follow their own paths (Reynolds et al., 2010). Static online content can often lead to higher cognitive workloads in learning with the processing of such information that must be worked through at each stage (Mayer & Mayer, 2005). Therefore, by incorporating the use of free-choice within the online learning unit we can provide opportunities to lower the workload for learners and to keep their interest and attention. The following hypothesis was raised:

- *Hypothesis 2 (H2):* comparing to exploring text-based information in order, the opportunities of free-choice in such digital content can bring better learning experience for learners in the online learning unit for immigration-oriented museum education.

Ahn et al. (2021) found a source of interactivity on web-based environment will increase the feel of control for users (for example: users could feel they have control over their actions; and they have a distinct voice). Sundar et al. (2014) also found similar results: in the virtual environment, via the actions route, users feel in control by their perception is extend by clicking and other interactive actions on the digital content. Instead of just hearing or watching a story or still information, learners feel that they are controlling and driving the learning peace, influencing the narratives, and building stories through playing a character in the virtual environment and building communications and interactions with the digital content (Heussner, 2019; Heussner et al., 2015). Based on these statements, the research assumed that:

- *Hypothesis 3 (H3):* digital content with interactivity can keep learners focusing on the learning in the online immigration-oriented learning unit.
- *Hypothesis 4 (H4):* playing as a character in the historical online learning unit can get learners involved in a higher level in the online immigration-oriented learning unit.

Audio can be used to support text content in the developed digital learning for a better learning results (Oberfoell & Correia, 2016). According to this conclusion, the research assumed:

- *Hypothesis 5 (H5):* using audio to support text content can help learners process information effectively in the online immigration-oriented learning unit.

Lastly, often history can be unfamiliar to current generations. The historical objects should be placed in the virtual environment, which is familiar to the audience such as a current map of Melbourne, to help provide ease of recognition. This familiarity will help to evoke feelings of connection for audiences between today and the materials from the past (Metzger & Paxton, 2016). The research proposed that:

- *Hypothesis 6 (H6):* using familiar imagery to help user form connections to the past as featured within the virtual immigration-themed learning unit.

3.2 Hypotheses Test Results

H1: integration of text and image versus images/text.

H_{10}: there is no difference between the digital learning content incorporating visual imagery with text and text- or image-only in imparting information to learners and helping them understand the information in the online immigration-oriented museum learning environment.

H_{11}: there is a difference between the digital learning content incorporating visual imagery with text and text-only content in imparting information to learners and helping them understand in the online immigration-oriented museum learning environment;

or there is a difference between the digital learning content incorporating visual imagery with text and image-only in imparting information to learners and helping them understand in the online immigration-oriented museum learning environment.

Figure 3 shows the median marks about how different types of digital content can help learners understand the information and knowledge of physical exhibits in immigration-oriented museums. It shows that the median mark of integration of text and image are slightly higher than text or image-only presentations.

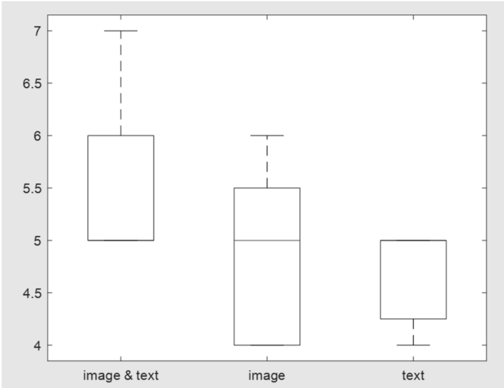

Figure 3 Visualize summary statistics for H1

The test decisions for the null hypothesis, H_{10} is h=0, as shown in Table 1, indicates a failure to reject the null hypothesis at the 5% significance level. However, the small values of p (p-value=0.1218, p=0.1144) casts doubt on the validity of H_{10} as there is about a 90% probability that the combination of image and text can better impart information than text or image only. Therefore, although it is a failure to reject the null hypothesis H_{10}, incorporating graphics with text can indeed help learners process and understand information better than graphics or text only to a great extent.

Table 1 H1: hypothesis testing results

	Hypothesis test result (h)	p-value
H_{10}: there is no difference between the digital learning content incorporating visual imagery with text and text- or image-only in imparting information to learners and helping them understand the information in the online immigration-oriented museum learning environment.		
H_{11}: there is no difference between the digital learning content incorporating visual imagery with text and text- or image-only in imparting information to learners and helping them understand the information in the online immigration-oriented museum learning environment.	0	0.1218
there is a difference between the digital learning content incorporating visual imagery with text and image-only in imparting information to learners and helping them understand in the online immigration-oriented museum learning environment.	0	0.1144

H2: text with free-choice versus text without free-choice.
The median marks related learning experience for text with free choice or not are visualized in Figure 4. The boxplot shows there is a difference between the median rate of two situations. The test decision was conducted to test the strength of this observation. H_{20} was set up as there is no difference between text with free-choice and text without free-choice to bring virtual learning experience to learners in the online immigration-oriented learning unit, where H_{21} was built as an alternative hypothesis- there is a difference. The result is p-value=0.143, where there about 85% possibility to support that text with free-choice can bring better online learning experience than text without free-chice. But the hypothesis test result (h)=0, which is a failure to reject the null hypothesis.

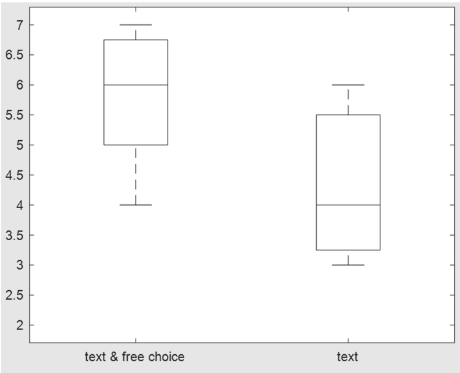

Figure 4 Visualize summary statistics for H2

H3: digital content (text/image) with interactivity versus digital content (text/image) without interactivity.
H_{30}: there is no difference between digital content with or without interactivity to keep learners on the learning experience and explore information in the online immigration-oriented learning unit.
H_{31}: there is a difference between digital content with or without interactivity to keep learners on the learning experience and explore information in the online immigration-oriented learning unit.
Figure 5 lists returned test decisions for H3. The comparison between text/image with interactivity and text/image without interactivity from two perspectives: 1) how much it can keep learners focusing on the learning, named as ‘Attraction’ in Figure 5; 2) How much it can help learners to explore information effectively, known as ‘Virtual learning experience’ in the figure. The four quadrants (hypothesis test result/h=1, p<0.05) indicate the rejection of the null hypothesis at the Alpha significance level=0.05. The output of arguments support H3.

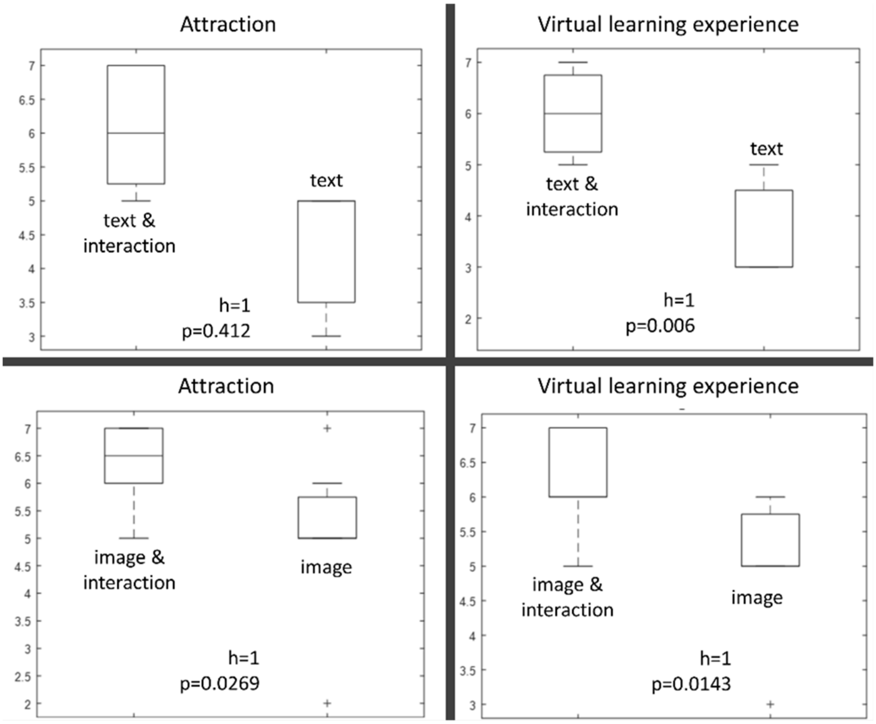

Figure 5 Hypothesis testing results for H3

H4: building character and keep focused.

$H4_0$: there is no correlation between the being given the opportunity to build a character in the online immigration-themed virtual historical learning unit and the ability for learner to keep focused.

$H4_1$: there is a correlation between the being given the opportunity to build a character in the online immigration-themed virtual historical learning unit and the ability for learner to keep focused.

Figure 6 displays the linear regression modelling for the relationship between the building of character and the level of involving (Pearson correlation coefficient/PPC=0.5953, p-value=0.0072), where the p-value rejects the null hypothesis and the PPC indicates there is a positive relationship between these two elements. Additionally, the review comments from the participant also supported H4, where participants expressed building a character in the virtual learning environment consequently making them eager to see the results.

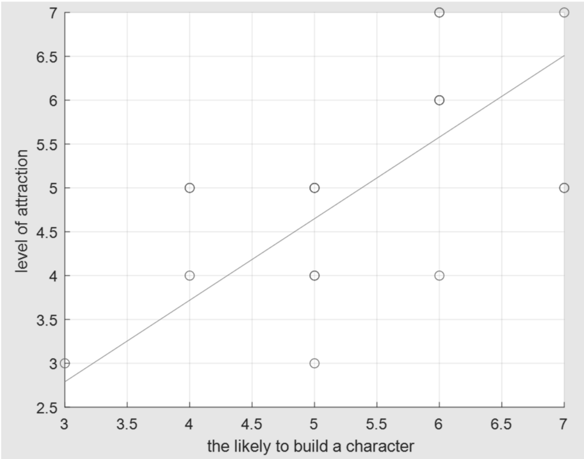

Figure 6   Linear regression relation between building a character and getting involved

H5: audio with text versus text.

For Step 2 "Knock the door to immigrate to Australia", as featured in Figure 1 (presented in Section 2.1), audio content has been included to support static text content. The learners explored these contents to understand the requirements and processes to get into Australian under the selected period. Based on users' selection of useful content and their rates of Step 2 supporting their understanding, the test was conducted to decide:

H_{50}: there is no difference between text with audio and text without audio to impart information.

H_{51}: there is a difference between text with audio and text without audio to impart information.

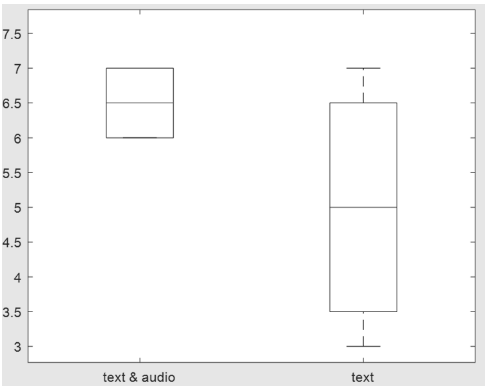

Figure 7   Visualize summary statistics for H5

Figure 7 lists the boxplot for the two solutions, and the test decision results are hypothesis test result =0 and p-value =0.2474. This set of data is insufficient to reject H_{50}, even though there is a 75% possibility that text with audio can better help learners process information effectively. Therefore, further work is needed to explore and ultimately determine if learners have a preference for content that is integrated with audio rather than text or image only content.

H6:

The Step 4 "Explore life behind the door", as featured in Figure 1 (presented in Section 2.1), used locations in current city maps to connect things in the past, where locations are familiar to current learners but things in the past are not. Figure 8 lists the rank of useful and helpful for Step 4 to participants (ranking from 1=most helpful and useful to 5=least helpful and useful). More than 60% of participants think the step is somewhat helpful and useful, and the most selection rank is 2=helpful and useful. Additionally, the review comments indicated that such organizations can effectively allow learners know what life would look like in the past. These basic data is a positive indicator for H6, which means it is worthy to develop the virtual learning based on the hypothesis. Further information is needed to collect in the next step to decide H6, such as the time that participants need to finish the task with and without the familiar elements to build connection.

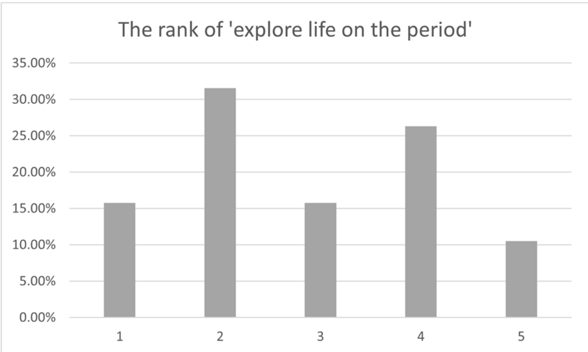

Figure 8 Visualize summary statistics for H6

3.3 The Analysis Results of Usability and General Attitudes of the Online Interactive Learning Unit

The research used the usability system raised by to evaluate the usability of the developed working prototype (Nielsen, 1994). The Nielsen process has been widely used in usability research (Jiménez et al., 2012), as a method to evaluate the design and user interactions of systems. Nielsen (1994) said system acceptability is the question of whether the system is good enough to satisfy all needs and requirements of users and other potential stakeholders, where the usability is a major concern of the system acceptability. The scale for usability measurement is a seven-point Likert Scale. The research specified the minimum level which would be acceptable for release of the system to further step as the mean rate of usability in each attribute should not be smaller than 4. The results are used to answer RQ2. Table 2 lists the numerical analysis of the usability evaluation.

Table 2 Numerical analysis for usability of the online interactive learning unit

	Question	Mean	Std Deviation
1	It is easy to learn how to use it.	4.47	1.43
2	It is easy to understand the interface elements and their functions.	4.32	1.81
3	The logical process of the design is easy to understand, within which I can easy figure out how to progress the learning experience.	4.47	1.31
4	The efficiencies of the designed functions/processes are good, and it requires the fewest steps possible to accomplish what I want to do with it.	3.47	1.70
5	What I see is match what I expect.	4.79	1.06
6	The design of the mistake-correction mechanism is easy to understand, which allows me to know how to recover mistake quickly and easily.	4.26	1.45
7	I am satisfied with the layout.	4.89	1.33
8	It will be fun to use it.	5.11	1.17
9	The learning unit is attractive for me.	5.05	1.19

- Learnability is an especially critical component for usability as it can ensure the system should be easy to learn so that the suer can rapidly start getting some work done (Nielsen, 1994). The questions 1 to 3 in Table 2 were used to evaluate the learnability, which meet the minimum level of acceptance.
- The efficiency of the learning unit was tested in Question 4. The results show that the learners did not agree that the system was efficient to use. Their comments suggested that perhaps the navigational design of the prototype needed to be adjusted to improve the efficiency of use.
- The results for question 5 indicated that match between the design and the real world is accepted, making information appear in nature and logical order.
- The error rate of the designed learning unit is at a low and accepted rate, where learners can easily recover from errors if they do make some (Mean=4.26, Std Deviation=1.45 in question 6).
- The evaluation outcomes of question 7 to 9 in the table indicated the system passed the minimum level of acceptance for satisfaction, being pleasant to use, being like it, and being satisfied when using it (Nielsen, 1994).

The research created a probability distribution object by fitting a kernel distribution to the data shown in Figure 9 for the two groups of level of inspiration to visit the physical immigration museum. The mean value of each groups is not smaller than 4 (the histogram shows that the data has two modes, one with the mean rate being near to 4, and the other one with the mean rate being near to 6). The finding is a very positive indicator, especially for the second group, for the economic values of the online interactive learning unit, and is evidence to prove the mutually beneficial relationship between online platforms and physical venues for museums.

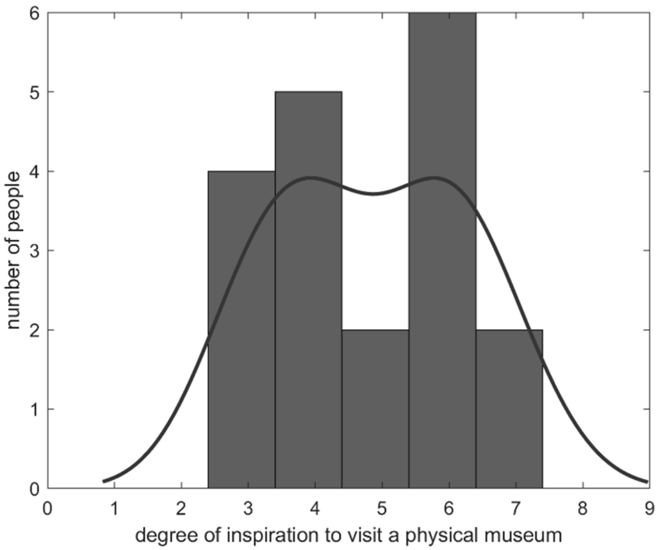

Figure 9 Kernel distribution of how much the online learning unit can inspire learner to visit the physical museum

4 Conclusion and Discussion

The research demonstrated the advantageous capabilities of using an interactive online learning unit to benefit learners unable to attend and engage in the physical museum. The hypotheses tests were used to test the effectiveness of the designed and deployed digital content in the online immigration-oriented learning unit transferring information in physical exhibits to virtual learning environment, where most of the hypotheses were proved, creating a connection with learners, and keeping learners focusing on the online learning experience. The evaluations disclosed that the mapping of using virtual graphics with text to display information in the physical immigration museum into online learning environment can match the information processing for virtual learners to a great extent. Adding the opportunities of free choices for learners existed in physical museums to digital passive text content can help learners reduce memory working loading and allow them to keep interesting in learning to a large degree. Taking advantage of digital content by adding interactivity to still digital content and the ability to build a character/avatar can evoke the feeling of control over learning processes, involve virtual learners into a higher level where they would like to pay more attention to find out how the online learning unit will be processed and go to the end, and even has the chance to build the empathy with the past through the understanding and engagement. On the other hand, further work is needed to clarify the learners' preferences for content that is integrated with audio rather than text or image only content. Also, further data is needed to test H6 that the use of familiar imagery helps users form connections to the past as featured within the virtual immigration-themed learning unit.

The functionality of the online interactive learning unit is sound, and users can use this functionality, which is demonstrated with most mean rates reaching the level of system acceptability. We can conclude the design of interactive human-computer interfaces in the online learning unit can communicate information from the physical museums with learners in a friendly and effect way. However, there is a concern with the efficiency of the design. Even though the research used the familiar navigation methods of ‘back, forward, next and previous buttons’ to help learners navigate through the learning experience the results of the survey have highlighted, that further refinements, may be required to clarify the navigational controls and designs for the learners.

Additionally, the results showed that the digital age does not mean museum stop collecting objects or curating physical exhibitions and funding their brick-and-mortar platforms (Rellie, 2006), while these onsite activities make museums distinct in digital age. The physical museums are the beginning points for museums digital transformation, and they give digital activities purpose and edge. The digital online interactive learning unit based on museum physical learning experience can bring economic values for museums by inspiring virtual users to visits physical museums. Meanwhile, it broadens the marketing channels for museums in the digital area.

These results offer an insight and toolbox for researchers and museum educators who would like to study or to introduce informal online interactive education. The discussed results can be used as references for using web-related technologies to benefit the learners who are unable to visit museums and to broaden the reach of museum exhibit beyond the brick-and-mortar. Based on the findings from this paper, the next stage of the research is to iterate the prototypes designs and to deliver a fully developed online learning unit. When the next iteration of the online learning unit is available further testing will be conducted to review the performance measurement by inviting a focus group of learners to interact with the online learning unit and perform a set of-pre-defined test tasks. Navigational, time-on-task, and error data provide focus point examples for the future focus group testing. The results and findings from the testing will then be used to inform further designs of online learning units.

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Creativity During the Coronvirus Pandemic: Inspiring Language Learning at University During Lockdown

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Abstract
Purpose – One of the pleasures of learning a foreign language is the interaction with classmates and instructors it entails. With schools closed because of the pandemic, for many learners around the world the immediacy of the language classroom has been replaced by screens. Even worse, the creative aspects of developing skills in a second language do not extend well to the learning management system-based solutions typically favoured by colleges and universities.
Design/methodology/approach – What this paper does, then, is to explore ways of fostering student creativity during lockdown. We specifically cover what can be done for students learning English as a foreign language, and do this in two ways: first with regard to creativity in the case of discrete skills such as writing and presenting, and second as a progression in terms of students' level from beginners to more advanced learners. In other words, we propose a comprehensive approach for inspiring students to produce creative work in spite of challenging conditions.
To accomplish this, we focus on three aspects linked to creativity: how creativity has previously been envisioned in education; creativity as it relates to students' grade level and specific skills; and key learnings about student creativity during the lockdown period and what we can take away from them.
Findings – There are several ways in which creativity can suffer when learning takes place without access to the physical campus. For example, overreliance on learning management systems promotes convergent thinking over divergent thinking. Skills that are in theory being honed are subordinated to the software's limitations. In addition to concerns about skill development, task design is also an issue. Many creative tasks require an incubation period and an iterative process, both of which need supporting. For language learners, the balance between structure and creativity in task design is a fine one requiring a nuanced approach. In short, creativity is a critical aspect of learning if learning is to mean more than rote memorization.
Originality/value/implications – Participants will find that the solutions we discuss are all relatively simple in terms of their technical complexity, will be posted online for their own use, and can be adapted to a number of classroom contexts.

Keywords: creativity; online learning; teaching methodology; language learning; skill development

1 Introduction

"You want the benefits of free trade? Food is cheaper. Food is cheaper, clothes are cheaper, steel is cheaper, cars are cheaper, phone service is cheaper. You feel me building a rhythm here? That's 'cause I'm a speechwriter and I know how to make a point. It lowers prices, it raises income. You see what I did with "lowers" and "raises" there? It's called the *science of listener attention*. We did repetition, we did floating opposites and now you end with the one that's not like the others. Ready? Free trade stops wars. And that's it. Free trade stops wars!"

(Redford et al., 2001)

1.1 The science of listener attention

The scriptwriters here are of course alluding to the work of Max Atkinson, a UK researcher and speechwriter who, in 1984, trained a member of the public with no speechmaking experience to give a highly effective address at a national political convention. Atkinson studied the interplay of human speech and body language and produced a body of work that described then current political speechmaking: volumes that relied on video evidence of audience reaction rather than prescribed rhetorical techniques of Greek and Roman origin (Atkinson 1984, 2004).

Audience attention offers an insight into how novice communicators such as second language students can enhance their ability to inform, influence, and inspire. The purpose of this paper is to discuss educational approaches to unlocking audience attention during a time when face to face interaction was impossible, and online learning meant curriculum and syllabus revisions needed to be recreated almost overnight.

We focus on the oral-literate connection – that is, speaking and writing and how they interact. In L2 contexts, writing and speaking not only support each other, but also further the development of other language skills and facility with multiple medias and novel technologies (Belcher & Hirvela, 2006). We particularly discuss how an emphasis on creativity spurs a drive among students to produce more effective, audience-oriented work.

The paper first places creativity into a broad framework of approaches, then shows its operationalization in L2 contexts, and concludes by detailing how we dealt with presentation classes and writing skills classes during lockdown, using creativity as a tool to better attune our students to the role of audience attention.

1.2 Contextualizing creativity

Creative endeavours are characterized by either two or three attributes. There is broad agreement about originality and usefulness, with the third, "surprise", being somewhat more subjective (Csikszentmilalyi, 2103; Kaufman, 2019; Meusberger, 2009). The body of research behind creativity reveals a number of dilemmas and tensions: is it a process, a product, or a combination of both? What is the relationship between structure and chaos? How do implicit and explicit knowledge shape creativity? Is divergent thinking a necessary part of problem-solving? To illustrate the complexity of the issue, Sternberg and O'Hara proposed five theoretical relationships between intelligence and creativity, as shown below in Table 1 (Sternberg & O'Hara, 1999).

Table 1. Creativity and intelligence as constructs

1. Creativity is a subset of intelligence
2. Intelligence is a subset of creativity
3. Creativity and intelligence are overlapping constructs
4. Creativity and intelligence are part of the same construct
5. Creativity and intelligence are distinct constructs

Corazza and Lubart show that all five relationships are still extant, with relevant theories and empirical data to back them up (Corazza & Lubart, 2021). They then map every major theory of creativity using space and time (approximately: how wide the thinking landscape is, how much time is available, and how tight or loose the stated space and time is). In other words, they propose a quadrant-like continuum into which every current theory of creativity, including all five of Sternberg and O'Hara's hypothetical relationships between intelligence and creativity, can be placed.

Corazza and Lubart's paper is not only a future classic, it also has a lot of explanatory power when it comes to lockdown learning. Specifically, if time is tight (i.e. a "live" lesson broadcast via the internet) students' scope for creativity will be limited. Oppositely, on-demand classes theoretically allow for a more nuanced response from the participants, permitting more creativity. Likewise, if the space is tight – for example, a drop-down menu of multiple-choice answers on a learning-management system (LMS) such as Moodle, little creativity can be expected, whereas an essay prompt on the same LMS gives students the opportunity to make something unique.

2 Creativity in Education

According to the APA dictionary of psychology, creativity is a durable trait, and one which allows for the display of "originality, imagination, and expressiveness" (VandenBos, 2007, p.264). From a UK-based perspective, expecting students to perform creative tasks is now normal at all levels of education. If Sir Ken Robinson's TED talk on creativity in schools seems run of the mill 15 years after it was recorded, it is because of the amount of progress that has been made. The Durham Commission report of 2019 stated that all subjects require creativity baked into their teaching, saying "creativity makes a valuable, indeed vital, contribution to learning in all subjects." (James, et al., 2019, p.23). Scotland has mandated a "national creative learning plan", and in England the oft-cited Tallis Pedagogy Wheel has been adapted to suit online learning on tablets, now known as "padagogy" (Carrington, 2016).

2.1 Creativity in L2 Education and Japan

However, creativity is a word that does not translate well into every language (Mpofu et al., 2006), and its societal value is seen differently by English-speaking and non-English speaking cultures (Niu, 2006). As such, there are implications for foreign language instructors, especially those teaching English in foreign settings. In Japan, on one hand a great deal of lip service is paid to the idea of students' active learning and creative pursuits, but on the other hand, multiple choice tests and university entrance exams still dominate stakeholders' perceptions of educational quality (Ockey, 2017).

As such, one of the tensions for foreign instructors in Japan is the extent to which they are willing and able to accommodate such perceptions while discharging their duties in ways that equip students with 21st century skills. Expressiveness, imagination, and originality are the backbone of creativity, and connected to other domains such as critical thinking and problem solving. Each of these three is a requisite for success in second language learning (L2) and, as such, it can be said that there is no route to L2 gains without at least some creativity on the part of instructors and learners (Coreil, 2007). Thus, on one side we have an educational climate that does not reward creativity, while on the other we have an endeavour that cannot succeed without it. Now we need to add in a global pandemic to the mix.

2.2 L2 in the Lockdown

The academic year in Japan runs from April to March. Universities were fortunate in that the Covid-19 cases started to peak slightly before the semester started, meaning that action plans for the whole semester could be implemented without as much trouble as in places where cases expanded in the middle of a semester. While many classes could be simply put online, interactive situations such as language learning presented problems due to the lack of time to prepare, issues of student access and internet speed, and how sustainable the curriculum would become over time.

Within Japan, many institutions initially tried to make the classes available in real time, but found that too few students were able to fully participate. During the first few weeks of the semester, administrators realized that on-demand approaches were more forgiving, and asked instructors to relax standards for deadlines and file types to accommodate students who were struggling. A broad consensus that speaking classes could be held in real time if others (reading, writing, etc.) were conducted on-demand soon emerged.

Real time online classes clearly fall within the tight time / tight space designation of Corazza and Lubart's model. Participants are constrained by the format, and need to do what they can to work fluently given the variable quality of each member's connection.

On-demand classes offer a much more positive space in which students can exercise creativity. Given that they are not under time pressure, and that their performance is not affected by other participants' technology, students are relatively free to produce high quality work. Further, task design can successfully accommodate a wider range of interests and formats when compared to real time situations. Finally, within L2 education, there are always activities that are worthwhile, but not necessarily during on-campus lesson time. Examples include improving or perfecting output once a basic framework has been agreed, and a certain threshold reached. After this point, "delicate scaffolding", which means that students take on more responsibility for the quality of their work. Importantly, learners need to provide some of the meaning for themselves, rather than having everything supplied for them (Wilson, 2016). In this paradigm, divergent thinking, expressiveness, imagination, and originality have an opportunity to come to the fore.

3 Creativity in the Writing Class

Writing with a focus on how the audience will "hear" the words has been a major theme since the 1940s (Graves & Hodge, 1943). Partridge extended this approach to how punctuation affects an audience's response. What these books did for aspiring writers, Zissner achieved for first language students (Zissner, 1976) and then Swales and Feak for L2 learners (1994). So this is not a new idea, but also not one that lends itself well to non-elective classes with 30 – 40 students. Having said that, the forced change of mode to online, on-demand classes created an opportunity for a slower, more deliberative pacing of materials, with a stronger than usual focus on how the language sounds when read.

Instead of aiming to master the typical 5-paragraph essay a choice was made to focus on the shorter, more structurally integrated texts students will often encounter as readers. Table 2 shows the structures presented during the semester.

Table 2. Essay structures

1. General-specific.
2. Problem-solution.
3. Cause-effect.
4. Time Order.
5. General-personal.
6. Comparison.
7. Plus-minus.

When compared to a 5-paragraph approach, these can be more easily scaffolded delicately (Wilson, 2016) and are also more amenable to divergent thinking. For example, once the students have been exposed to General-specific and Problem-solution structures, they can be given a topic to work with and choose which structure is the best fit. Taking "1st grade at university" as a theme, for instance, a student whose 1st grade life left something to be desired, and who can now see what was required to make it better, could write an essay that the audience would likely find engaging. Oppositely, a student whose 1st grade experience was excellent, awful, or poor but with no obvious solution, would do better with general-specific.

The structures were presented sequentially as listed above, and students were asked to produce one essay to show they could manage a given topic, and then in the following week were introduced to a new topic and asked to choose between structures. By the end of the semester, the students were fairly able to express themselves more creatively than the level check in the first week suggested.

Table 3 shows how a single topic accommodates all 7 structures, at least in theory. The students' personal circumstances might affect how well each structure matches the topic, in this case, "maternity harassment" – a widely reported issue in Japan.

Table 3. Essay structures on a theme of maternity harassment

1. General-specific: Issue 1, issue 2, issue 3.
2. Problem-solution: What the concern is, and how to remedy it.
3. Cause-effect: Social / structural reasons & their impact.
4. Time Order: Grandparents' generation, parents', my generation
5. General-personal: What most people think; what I think.
6. Comparison: Other countries / other workplace problems.
7. Plus-minus: Major drawbacks, followed by any benefits.

As can be seen, all seven are possible. In the case of plus-minus, a reversal to minus-plus is more likely to win the audience's ear. The plus points of maternity harassment require some thinking about, in fact, but the rise in public awareness and changes in company policies clearly show that more is being done and that the situation is improving.

Learning to write via online classes is never likely to be a popular choice, but the students' uptake was surprisingly positive. As will be explained in the limitations section, it is not possible to directly compare with an ordinary semester of L2 writing instruction, but given the circumstances during 2020, we can say that the students made progress not only with their writing, but also with their appreciation for what an audience wants, and how to creatively address that. In order to accurately show how the lessons were presented in an on-demand fashion, example slides have been posted online for ICOIE participants to consider.

4 Creativity in the Presentation Class

Zissner, Graves and Hodge, and Partridge are forebears of the approach Atkinson took when creating his early work (Atkinson, 1984). Instead of using paper and the written word, though, Atkinson's source was video recordings of speeches, which included close attention to the audience's response to what the speaker was saying and doing. There are too many more recent resources to mention when it comes to modern presentation skills based around an audience-centric approach, so we shall mention just two. The first is by Graham Davies, a regular political speechwriter, professional speaker, and frequent television guest. His book (2010) is a direct descendent of Atkinson's, but rather than focusing only on political speeches, it covers a range of presentation and public speaking situations. For interested readers, *The Presentation Coach* may be the single most useful resource available. Second is *Can I change your mind?* by Lindsay Camp (Camp, 2011). Ostensibly a book about writing, it "should" be in the previous section, but anyone picking it up will immediately see how well it fills a gap in the presentation skills creativity niche.

Creativity in presenting effectively is more challenging than in writing because we now have to incorporate visual and vocal aspects to the written (verbal) ones. As such, an umbrella term to encapsulate the whole of the online experience was thought to be helpful. Adapted from Provost we selected “musicality” as a theme for the semester, as it was felt that this would encourage, motivate, and ultimately push students to new levels of creativity (Provost, 2019). While Graves and Hodge and Partridge were very much concerned with the prosody of what they produced, the presentation class literally asks students to consider their output in terms of how musical it will sound to an audience. During the level check week, even the most experienced student presenters admitted that this was a new idea for them.

Seven ideas that promote the idea of musicality in presenting were taught in sequence, and students were asked either to apply them to previous work they were proud of, or to incorporate the ideas to new work they were developing. Like the writing class, this pushed them to think divergently. The ideas are shown below in table 4.

Table 4. Promoting musicality in a presentation skills context

1. Matching the purpose to an effective structure.
2. Sharpening an SPQR or Pyramid structure.
3. Verbal musicality and utterance length.
4. Lists of three.
5. Alliteration.
6. Contrasts.
7. Vocal musicality through pauses and stress.

Ideas three to seven are common to Provost, Camp, and Davies’ work. The first two ideas are adapted from a Presentation Bootcamp regularly held at the university and relate to whether the content is best presented as a problem to be solved (situation, problem, question, resolution) or as a general-to-specific pattern (known to our students as a “pyramid” presentation). Once the content’s purpose is clarified and a suitable structure is wedded to it, verbal and vocal musicality further challenges the students’ creativity and is suitable for subtly delicate scaffolding.

As with the writing class, definitive statements about students’ growth is not possible, but again, they showed a strong amount of interest in the concept of musicality when presenting, and either adapted materials or created new ones in interesting and useful ways. Returning to the APA’s definition of expressiveness, originality, and imagination, we can say that the class was successful despite the fact that none of the members ever interacted in person.

4.1 Example online content

In order to take advantage of the possibility of colour graphics and to understand how the materials from the writing class and the presentation class were displayed to students, selected example materials will be placed online for readers who wish to see them. The relevant url is: http://pc1971.weebly.com/

4.2 Grade appropriacy

What we have seen so far is an oral-literate approach to L2 creativity during a period when in-person classes were not possible. Novel ways of connecting with learners were taken in both writing and presentation-related classes. One further issue that could be addressed is what to do with higher level students, such as those more advanced in their studies, or if the pandemic continues, which at the time of writing, in Japan at least, seems quite likely, and previous students from theses classes need to continue in an online capacity.

For the presentation class, musicality has no upper limit, but to only focus on one theme for a second year, or with highly capable students might be a waste. Other potential directions include scalability – the idea that the amount of time available for a presentation is somewhat fluid and often outside of the presenter's control. This is frequently true in the real world when, for example, there are miscommunications, technology problems, or the most important audience member – such as a boss – is running late. Scalability forces presenters to become creative in their approach to planning, practicing, and presenting, so it is a highly worthwhile skill to pursue.

As for more advanced level writers, de-writing their own compositions is one possibility, as is improving something they wrote before and are proud of – an idea taken from the presentation class. Further, rewriting tasks, such as taking an acceptable but not ideal piece of writing and improving it offers a lot of potential for developing the students' creative capacities and understanding of how to get, keep, and direct audience attention. Examples of these ideas are also posted online at: http://pc1971.weebly.com/

5 Limitations and Future Directions

During lockdown it was not possible or desirable to set up experimental conditions that might affect how well students learn, or their other outcomes such as grades or credit. As such, claims about the effectiveness of learning during lockdown should be approached with some caution. Furthermore, creativity is not an equally distributed ability, and nor is receptiveness to approaches that attempt to inculcate it. It would be unfair to assess students on perceptions of their creative output when modes of learning were suddenly switched, curricula were hastily rewritten, and financial and technological issues created imbalances in opportunities to fully participate and engage.

Qualitative, longitudinal studies are possible – preferably using low stakes and with minimal connectivity or bandwidth requirements – and could contribute to the current generation of students bouncing back from their experiences in 2020 – 2021.

As previously mentioned, administrators wanted relaxed deadlines and were concerned about sustainability of the curriculum. For good students, this is a positive approach to take, but a student who needs no accommodations for technology issues can easily take advantage of the situation. Likewise, delicate scaffolding offers an opportunity for improved performance, but not all students will necessarily choose to try. For L2 learners, on-demand classes can actually be a rare chance for reflective practice. For "shy" class members, expressiveness, originality, and imagination time outside of the classroom might be exactly what they need. Yet students should not be penalized for not seeing things that way during what was a trying time.

Questions of how students return to normal learning and how best to frame or reframe the lockdown period in terms of outcomes and impact are important ones. Early indications from in-person classes held since April suggest that some learners feel there are chances that have permanently passed them by now, and that nothing can replace opportunities for exchange programs, study abroad, and gap years. For Japanese students in their 3rd or 4th grade at university, encouraging them to reframe their experience is probably a productive use of classroom time. This may well be true in other contexts where employment is strongly connected to university-age accomplishments and has long-term personal and professional consequences.

6 Conclusion

While creativity has differing levels of desirability in various cultures and education systems, there is no path to L2 development without some willingness to engage creatively (Coreil, 2007), and a focus on musicality in writing and presenting to better capture audience attention pushes students to be original, to use their imaginations, and to express themselves. Regardless of language and culture, an appreciation of an audience's needs is a valuable commodity, and this paper showed to ways to attune learners to those needs and enable them to make themselves heard as never before.

As the current cohorts caught up in lockdown learning start to look for work and embark on their early careers, the way they position their schooling will affect how others see and treat them. For this reason alone, promoting creative approaches to projects is well worth instructors' extra efforts.

Looking to the future in this way, we showed a route to higher levels of L2 performance, and discussed the idea of reframing the lockdown learning experience so that students can regain their equilibrium. Indeed, a reframing project is an excellent example of how musicality can creatively unlock an audience's attention.

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Language Learning by Synchronous CMC: A Study in Japan

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Abstract

Purpose – The aim of this study is to examine the benefits and drawbacks of synchronous computer-mediated communication (CMC) from the perspective of Japanese undergraduate university students who have completed year-long English language courses with weekly speaking-focused lessons. The focus is placed upon students' thoughts and attitudes toward online versus face-to-face interactions and which of these approaches they prefer.

Design/methodology/approach – Students' feedback was collected through a self-reported online survey provided to six classes of students on completion of one of three courses taught by one of the authors. The question items were adapted from Spitzberg's survey on the model of computer-mediated communication competence (2006) which analyses effectiveness, expressiveness, and motivation with respect to students' online learning experiences. Tabulated data are presented in the results and are discussed together with qualitative feedback from students and additional observations made by the instructor during the class.

Findings – The results showed that many students had a growing willingness to engage in online spoken language activities and demonstrate an increased enthusiasm toward the CMC learning approach when compared to the in-class English language activities they had experienced previously. Students also showed considerable interest in utilizing internet resources when completing their assigned tasks. However, some students' commonly exhibited self-consciousness when asked to speak English during online meetings, showing a reluctance to interact with the instructor or their peers. Some students also reported technical difficulties and unique personal circumstances as factors detrimental to their motivation and enthusiasm for learning.

Originality/value/implications – The context of a global pandemic has presented a unique opportunity to assess the value of online learning tools as they have suddenly become a necessity. This is especially significant in Japan where previously there has been very little experimentation with remote learning and limited adoption of online resources. This study surveys a group of Japanese students' very first fully remote learning experiences using video conferencing. While the sample size is small, the findings indicate that understanding individual students' technical and psychological circumstances is indispensable for mitigating undue stress and encouraging engagement and enthusiasm. In addition, recognizing how Japanese students' unique socio-cultural attitudes may influence trends in their learning preferences, specifically with regards to online interactions, presents it as an important area to be explored in future research.

Keywords: computer-mediated communication, online learning, videoconferencing, student engagement, speaking skills

1 Introduction

The Covid-19 pandemic has caused a radical transformed how students are taking their regular school lessons the world over. Due to campus closures, a large number of students worldwide have been required to take lessons remotely utilising computers and the internet. Japan has responded with an unprecedented effort to implement digital technologies as a result of the pandemic and education is no exception. With regards to language teaching, in particular, the pandemic has radically changed the teaching approaches and the tools teachers use. Synchronous computer mediated communication (SCMC) is one such approach to be used as a replacement for traditional face-to-face communication in the classroom. This study explores the benefits and drawbacks of using video conferencing for SCMC with respect to observations and feedback gathered from students across three yearlong English verbal communication courses at two Japanese universities.

1.1 Synchronous Computer Mediated Communication

According to Kern, Ware and Warschauer (2016, p. 542), the concept of CMC originated back in 1960s. In 1990s when the internet and email messages were readily available, text-based CMC, involving the exchange of information between individuals became popular. CMC is divided into two form: synchronous and asynchronous. For English language education, asynchronous CMC, such as *emails* and *bulletin boards*, has a longer history (Alahmadi, 2017). Some drawbacks regarding asynchronous approaches include instructors' difficulty in controlling classes and students' inability to keep up with the rapid pace of online discussions (Kern, Ware & Warschauer, 2016, p. 542). On the other hand, synchronous CMC has arisen as a result of the internet revolution enabling real-time communication.

With regards to language teaching in particular, studies reveal that, similar to face-to-face environments, SCMC has the potential to enhance students' communication skills and rates of language acquisition. A local study of video conferencing enabled English classes which looked at performance across fifteen weeks appears to confirm this potential (Lee, Nakamura & Sadler, 2018). International studies provide similarly encouraging results. Accordingly, SCMC was found to, "promote complexity and fluency in presentational tasks and complexity, accuracy, and fluency in interpersonal tasks" (Tecedor & Campos-Dintrans, 2019, p. 116). Students' participation was also found to be encouraged, with SCMC promoting deeper interaction among students and "offer[ing] opportunities for negotiation of meaning" (Helm, 2015, p. 199). SCMC is also reported to be beneficial for students intercultural understanding through online encounters (O'Down, 2016). The integration of SCMC into language learning was also found to help students raise their awareness of language forms and functions through active and interactive communication, developing their communicative competence (Zeng, 2017: O'Rourke & Stickler, 201).

While the use of CMC in language learning has been rapidly growing, prior to the 2019 coronavirus pandemic, education with video conferencing tools has remained outside of mainstream education programs (Helm, 2015, p. 197), and this is especially true in Japan wherein the use of digital technologies and the internet continues to be limited at most levels of conventional education (Aoki, 2010). As a result, synchronous

CMC research remains relatively scarce, with researchers presenting their findings reservedly. Further longitudinal research now needs to be carried out in order to more confidently evaluate the promises of this technology, and whether or not it can really substitute for traditional in-person classrooms.

1.2 Remote Learning and CMC in Japan

While digital technologies in education have become more important than ever the world over, it remains safe to say that much of this technology is not yet mainstream in Japan. Prior to the onset of the pandemic, few students would routinely use the internet and their personal digital devices to participate in schoolwork, with fewer still ever having experienced remote learning of any kind. It has been well understood for some time that compared to other members of the OECD, Japan's e-readiness has been severely limited (Lockley, 2011, p. 95). Before the virus became prominent in 2019, a government survey found that of 1,815 local education boards surveyed, 78% of elementary and secondary schools were not using any remote learning systems, and 73% had no plans to introduce them (The Japan Times, April 2020). There are several reasons for the continuation of this status quo including a government education policy which bans schools from approving any credits for lesson taken solely online, insufficient digital infrastructure on school campuses, and insufficient digital literacy among education providers and teachers (The Japan Times, April, 2020). Ironically, this has remained to be the case despite the fact that ICT courses in high schools have been mandated for almost 20 years (MEXT. 2011). Significant e-learning implementations have been achieved at some universities, but many universities are limited to using online content management systems, with any remote learning opportunities being a supplementary or experimental part of regular courses (The Japan times, May 2017).

With regards to language learning in particular, SCMC, whether text-based or video conferencing-based, has not been prevalent. Studies on synchronous CMC remain limited to specific applications of the technology, such as providing students with opportunities to interact with confident speakers of English outside of Japan (Yamada & Akahori, 2007; Iino & Yabuta, 2015). Meanwhile, there appear to be no studies examining the value of using these tools to facilitate remote interactions between teachers and students or among students, as an integral part of their language courses, at least prior to the pandemic.

This context has made an immediate transition from offline to online learning exceptionally challenging in Japan. However, now that digital devices have quickly been forced to become ubiquitous tools in students' daily lives, more research surrounding all possible remote learning approaches is desperately needed. Among these is video conferencing for language learning. How effectively will it serve as a substitute for face-to-face classes, enabling students to comfortably continue their English language educations?

2 The Study

2.1 Purpose

The purpose of this study is to examine the benefits and drawback of Synchronous CMC from the perspective of Japanese undergraduate university students, having completed their first majoritively online English language courses over the 2020 academic year. The study attempts to answer the following two questions about the SCMC component of these courses:

1. How do students perceive SCMC using video conferencing in terms of Spitzberg's *motivation*, *expressiveness* and *effectiveness*?

2. To what extent do students think that this new learning approach helps or hinders their language learning?

The focus is placed on examining students' thoughts and attitudes toward online versus face-to-face interactions and the instructor's observations of their abilities.

3 Methodology

3.1 Participants and Setting

First- and second-year university students from six elective English courses at two Japanese universities participated in the survey – 53 students in total. The same English instructor was in charge of these courses which were designed to improve students' general English communication skills. Students' majors include liberal arts, business, law, economics, science, and engineering. None of the students had experienced online learning before, and all were accustomed to lecture-style classes and paper-based materials, as is most common in Japan. However, all students have used smart mobile phones and online messaging applications for more than 5 years, and have some experience using computers for academic work.

The universities replaced all face-to-face teaching with fully remote alternatives from April of 2020 through January of 2021. Students in one of the universities took English remote lessons using the video conferencing tool *Google Meet*, while students at the other university used *Zoom*. While students using *Meet* were allowed to swich off their camera during the weekly lesson, while students using *Zoom* were required to have their cameras active according to university policy.

Course materials were uploaded in advance by the instructor to the individual university learning management system (LMS). Students were required to work on the assigned speaking tasks individually using the internet resources such as online language data and instructional materials. Each class in the courses was originally scheduled for ninety minutes over a 30-week period. However, in order to consider students' possible internet data limitations, the university instructed teachers to limit class durations to approximately an hour. While all students were required to join the video conferenced SCMC lessons, some students occasionally missed lessons due to scheduling challenges. These students were required to complete these lessons using the on-demand course materials and submit their work to the instructor via the LMS. A small handful of students who experienced internet connectivity problems were also able to join the live online lessons from computers on the university's campus.

During the weekly lessons, students were engaged in discussions or made to give solo presentations based on their assigned coursework, and whenever possible, show their own prepared materials or slides using screen sharing. Additional software features, such as dividing students into smaller concurrent session groups using Zoom's 'breakout rooms', were not used.

3.2 Student Survey

Students' feedback was collected through a voluntary self-reported online survey provided to students upon completion of one of six courses taught by one of the authors. The question items, adapted from Spitzberg's model of assessing computer-mediated communication competence (2006), focused on three factors: *motivation*, *expressiveness* and *effectiveness* with respect to students' language learning experiences through SCMC. While Spitzberg's model is originally deemed to be used to evaluate text-based CMC, these factors are also feasible to evaluate SCMC competence. Spitzberg (2006) and his followers (Bubaš, Radošević, & Hutinski, 2004) describe these factors as follows:

- **Motivation** "can be indexed positively by a range of constructs such as willingness to adopt new communication technologies, satisfaction, gratifications, and positive attitudes toward such technologies" (Spitzberg, 2006, p. 639).
- **Expressiveness** *(which may also be termed 'skills')* "is an attribute of the message that makes it appear verbally and nonverbally vivid, alive, and animated, as well as emotionally coloured" (Bubaš, Radošević, & Hutinski, 2004, p. 56).
- **Effectiveness** *(which may also be termed 'outcomes')* "is viewed as the degree to which various (and sometimes conflicting) communication goals are realized (or optimized) in CMC" (ibid).

Given that students were unfamiliar with online lengthy surveys, the short questionnaire including simple and straightforward questions were created. The questions were taken from Spitzberg' CMC Competence measure (version 5) (2006, p. 663). The questionnaire was provided to students via the university LMS at the end of the course. Students were encouraged to provide written comments together with multiple choice and yes-or-no questions. In addition to this feedback, additional observations were made by the instructors during each weekly class.

4 Findings

During Synchronised CMC lessons, students were observed to be fully engaged in the required spoken language activities. Outside of lessons, students were also found to be making productive use of online learning resources. However, students tended not to express themselves more than necessary during the video conferenced sessions. This observation was confirmed in the survey which found the majority had difficulty articulating themselves while live on video with their peers and were divided on their willingness to participate. Despite this, the majority believed they had achieved their speaking goals and had gained confidence throughout their respective courses. Students were all punctual in their attendance of the weekly lessons and with completion of their assignments. While technical difficulties were prevalent and curbed some students' enjoyment, these did not present any lasting hurdles and every student was able to finish their respective courses successfully.

4.1 Motivation

Seventy-five percent of students reported that they enjoyed talking and communicating with other students and the instructor in the target language via their digital devices (see Figure 1). The same number of students stated that they were able to avoid various distractions and stay focused on the lessons. There were four students who were particularly positive, stating that completing entire lessons online using video conferencing was an eye-opening experience.

Among the small number who gave negative responses, they most emphasised what they found to be the enormous pressure of being at the centre of attention in these meetings, including seeing their own faces as others see them. Some also expressed privacy concerns related to being on video in this way. A couple of students using *Zoom* commented as follows:

"I don't want to be stared at by everybody else on the screen and I even do not want to look at myself during the session."

"I wanted to turn off my camera when taking the lessons."

In addition, when students were not required to make their cameras active, almost 70% of students chose to keep them switched off during the sessions. Additional comments included disliking the mosaic of faces during the call, leading them to feel anxious about being so easily compared to their peers.

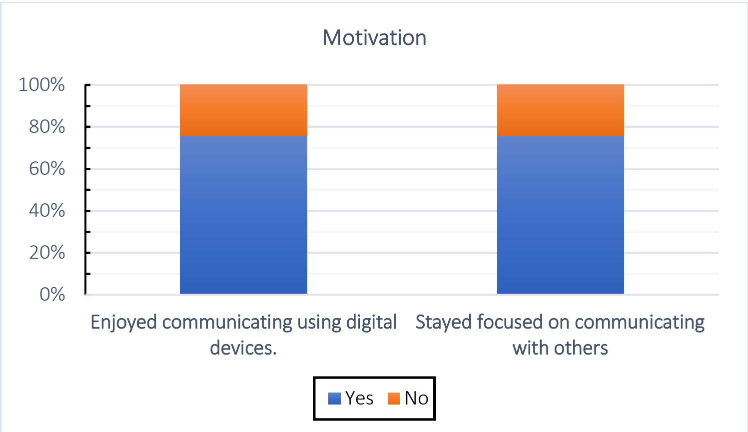

Fig. 1. Motivation

4.2 Expressiveness

Only 30% of students believed themselves to be expressive and well-articulated in what they wanted to say during sessions, with the remainder lacking such confidence (see Figure 2). Perhaps unsurprisingly, those who reported greater confidence exhibited greater development of their English-speaking skills than their peers.

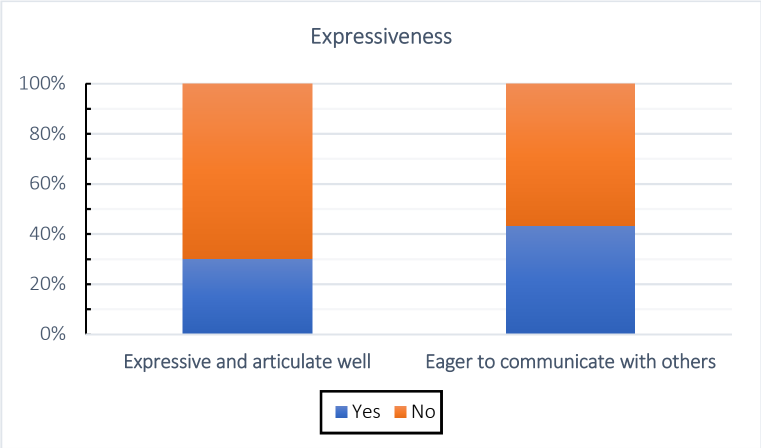

Fig. 2. Expressiveness

A slightly higher 43% of students reported a strong eagerness to talk with their peers during the sessions. Written comments indicated that those who were not so eager still sought to improve their speaking ability and confidence. One of the students stated as follows:

"Presenting in English every week helped me improve my presentation skills to express my own ideas. After taking this course I've realized that speaking skills gained by making presentations like this enhanced my existing other English skills."

More students than replied positively to these questions expressed in their written comments that the year-long courses satisfied them that they had gained additional confidence speaking English.

Lastly, there was one student who made a request for using *breakout rooms* in Zoom sessions to form much smaller groups for interactive activities. The efficacy of this feature may be a good target for additional research, especially as students become aware of its availability and begin to request it more often.

4.3 Effectiveness

Three quarters or 75% of students gained a sense of achievement through their interactions with each other and their instructors (see Figure 3). These students commented on their speaking confidence and some expressed pride in their accomplishments.

"Although I was often overwhelmed with school assignments, I think my speaking skills have improved since the beginning of the course."

"At the beginning of the course I had too many assignments to do and I thought this was getting out of hand. But once I got used to what I was supposed to do things got easier and I found I was enjoying what I had to do more."

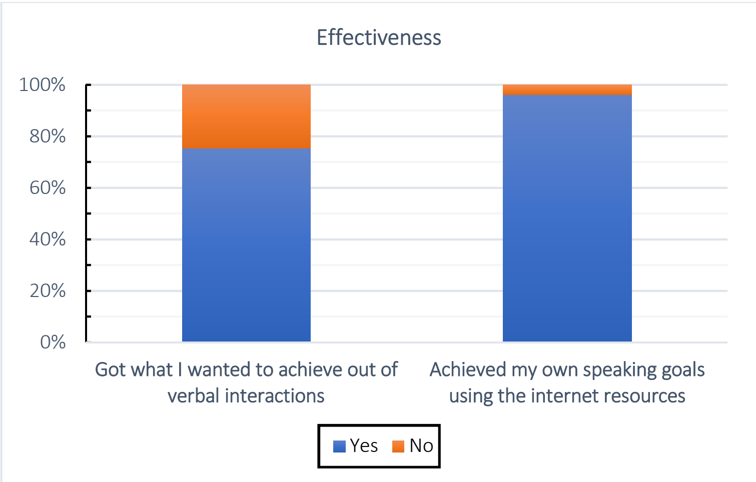

Fig. 3. Effectiveness

Almost all of the students believed they were able to achieve their own speaking goals using the online resources available to them. Students easily recognised the internet as an indispensable part of their language learning and ability to successfully complete weekly assignments. One of the students gave comments as follows:

"At the end of the course I felt a sense of accomplishment when I was able to undertake research on what I would like to talk about, prepare the slides and give a successful presentation."

Another student stated as follows:

"I feel like I was able to improve my speaking skills on my own for the first time in my life, through trial and error using the internet resources."

In addition, many students emphasised the importance and efficacy for them of receiving individual feedback from the instructor, which was provided as part of these lessons.

4.4 Technical Challenges

Approximately 20% of students experienced some technical limitations while attending their weekly lessons. Most noticeable were problems caused by poor internet connectivity, such as students' video or audio stream experiencing quality degradation or distortion for short periods of time. These situations necessitated students and the instructors repeat what they said several times. Students' computers would also occasionally disconnect from meetings despite no apparent signs of internet issues. Another issue was echoing of audio when multiple students were in the same university computer room, or issues with other background noise. There were also students who experienced confusion setting up or logging in to their *Google* accounts, the necessity of which would temporarily delay their ability to join the lessons. Lastly, due to incorrect settings on the university computers, students' microphones would very frequently fail to work. Overall, none of these technological distractions presented any major hurdle to instructors' delivery or students' completion of their courses. However, these challenges are indicative of the need for additional outreach to students prior to their courses to ensure they are comfortably and reliably capable of connecting to lessons. This may also include specially prepared guidance for students, and opportunities for students to provide feedback about their individual technical readiness.

5 Discussion and Conclusions

The world is currently experiencing an unprecedented transition from face-to-face to remote learning. Resultantly, there is a strong need for educators to equip students with the skills and confidence required to cope with online social interactions and be able to make full use of the digital tools necessary for success. The findings of this study on synchronous CMC demonstrate that video conferencing-based language instruction has sufficient potential to aid students in achieving their learning goals, improve their L2 English communication skills, and raise their speaking confidence. This result reflects the findings of similar studies carried out prior to this unique time in history (Tecedor & Campos-Dintrans, 2019: Helm, 2015).

Asian students learning English are reported to demonstrate uneasiness toward speaking English in CMC classrooms (Wu & Kawamura, 2014, p. 171), and this is somewhat corroborated in this study in terms of students lack of *expressiveness*. However, as Pérez Cañado (2010) argues, students who have experienced SCMC – such as the video conferencing employed in this study – tend to develop a strong willingness to attend similar courses in the future. In other words, while some students may experience similar or increased anxiety about interacting with their peers and instructors during synchronous CMC via video conferencing, these feelings did not impact their ability to achieve their goals, focus on their learning, or enjoy their courses. Further observations by the instructors during a brief 6-week return to face-to-face lessons at one of the universities, revealed students' apparent willingness to engage with their peers actually decreased compared to their online interactions. While more comparative research is needed, this may suggest that the integration of ongoing SCMC based learning components have the potential to improve outcomes for students who might otherwise lack sufficient confidence to fully express themselves in crowded classrooms. This may be especially true in Japanese high schools or universities where speaking up in class is less often encouraged compared to some of the more progressive learning environments overseas. Therefore, in these contexts SCMC courses using video conferencing may actually make it easier to encourage certain students' active learning and constructive social engagement when compared to traditional face-to-face language learning. Wu & Kawamuwa's (2014) also suggest students' relative reluctance to be expressive during SCMC may correlate with students' proficiencies or the pressure to use newly learned words and phrases (p. 171). However, comparisons between these findings and students' grades did not bear out this relationship.

This study was conducted in Japan at tertiary settings, and it has a limited scope with a small number of participants and time period. Since effective language learning is highly contextualised, more research needs to be done to examine what kinds of tasks and assignments need to be incorporated into language courses and to see the full scope of effective SCMC with this broader perspective.

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Evaluating Expectations and Engagement with Emergency Remote Teaching: A Cross-faculty Case Study of a Sino-British University

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Abstract

Purpose – The University of Nottingham Ningbo China (UNNC) was the first Sino-foreign (Sino-British) higher education institution to be established in the People's Republic of China (PRC). As the impact of the COVID-19 pandemic was being felt in the PRC in the Spring semester of 2020, the UNNC found itself under a strict lockdown, with many academic staff stranded overseas, and many of its 8,000-strong student population restricted from entering the campus. The UNNC was forced to devise a strategy for Emergency Remote Teaching (ERT), with large numbers of courses adapted for online delivery of teaching and learning (T&L), and assessment. This case study examines the student expectations and engagement over that period; and it explores the different approaches adopted for ERT and assessment, highlighting how a gap in skills and prior exposure to the relevant technology, for both teachers and students, influenced the experience.

Design/methodology/approach – Drawing on data from multiple surveys, supported by cross-faculty interviews and focus-group discussion, and reflective examination of individual experiences, this paper explores the different expectations, engagements and perceptions of facing the challenges caused by the pandemic.

Findings – Disconnects between expectations (of both staff and students) and how the semester actually evolved are exposed. Reasons for these disparities, including the unpredictable nature of the pandemic at that time, are examined, with suggestions for how to better insulate T&L moving forward. Training and familiarity with appropriate tools are identified as key elements for more smooth adaptation to the ERT T&L. This paper offers insights into best practices for managing similar situations in the future.

Originality/value/implications – The UNNC was the first Sino-foreign university to return to face-to-face T&L, in May 2020, and thus its experience is unique and of interest to the wider community. The identified disconnects between expectations and reality indicate clear opportunities for where institutions can bolster staff (and student) competencies, to better prepare for the 'new normal' in post-pandemic T&L.

Keywords: COVID-19; emergency remote teaching; new normal; student engagement; student expectations; staff upskilling.

1 Introduction

Most educators have lived the recent history which created the need for Emergency Remote Teaching (ERT). Briefly, the World Health Organization (WHO) was notified of a non-standard strain of pneumonia in Wuhan, the Chinese capital of Hubei province, on December 31, 2019. According to the WHO (2020), by January 3 2020, 44 cases were identified and within a few days a strain of coronavirus named SARS-CoV-2 (later called COVID-19) was shown to be the cause. By April 2021, we have witnessed devastating effects worldwide: the WHO (2021) reports that confirmed global cases sit at 139,501,934, including 2,992,193 deaths. The light at the end of this particularly bleak tunnel is that as of 14 April 2021, 751,452,536 vaccine doses have been administered; we obviously still have a long way to go, but organizations are beginning to consider what we have learned from this crisis and how to move forward.

One of the hardest hit sectors has been global education, with 1.6 billion learners in 190 countries and over 100 million school personnel affected at the peak of the crisis (UNESCO, 2021). An immediate repercussion from travel restrictions was to cut student mobility and the desire for it, particularly from Asia (Xiong *et al.*, 2020). This paper considers the case of the University of Nottingham Ningbo China (UNNC), a joint Sino-British venture which opened in China in 2004 and has grown to a student population of approximately eight thousand, including 7% international students (UNNC 2021).

In 2020, UNNC's spring academic semester was scheduled for a February 14, 2020 start, which was delayed to March 2 due to emergency government regulations. It was evident that with many staff and students unable to return to campus, online delivery would be the only viable option if students were to be able to continue their education, thus necessitating ERT.

UNNC's shift to ERT was assisted by teaching and learning (T&L) administrative support teams, such as the Library, Research and Learning Resources team, E-Learning Support, and IT Services, which allowed for the delivery of 469 online modules to 7,788 students by March 16, 2020. The majority of students were able to return to campus by May of that same semester, but a significant number of staff and students were unable to return to China at that time, necessitating a mixture of face-to-face and online teaching which continues to the present.

This paper examines the data collected by the institution on various forms of student and staff engagement and satisfaction, and supplements that with interview and focus group data along with our own experiences of both the ERT shift and subsequent effects this has had on pedagogical practice. In particular, we are interested in the areas in which there are disconnects between students, staff and institution, as these have implications on how T&L may be carried forward in a post-COVID-19 future.

This paper is of interest to teachers, policymakers and other HEI stakeholders because the disconnects between expectations and reality reveal opportunities to bolster staff (and student) competencies, and to better prepare for the "new normal" in post-pandemic T&L. We believe there is a chance to improve some of the previous problems in online learning that have been amplified by recent ERT learning interventions.

2 Background

To better grasp the current situation, we will briefly explore some research dealing with online T&L in general, then that which focuses on student engagement. We will then turn to some of the recent work examining issues directly arising from the implementation of ERT during COVID-19, before exploring the findings in our own institution.

2.1 Online Learning

There is a considerable history in looking at the effectiveness of both distance learning and, more specifically, online learning. We will concentrate on the latter, since that was the fundamental medium which UNNC used for course delivery from the onset of the COVID-19 crisis, and was an extension of the existing practice of using a virtual learning environment (in this case, the Modular Object-Oriented Dynamic Learning Environment, or MOODLE, which all instructors were required to employ as a central hub for learning resource repository and management).

Even before the pandemic, a number of issues have been identified in terms of online learning. Lieblein (2000) notes that it is the worker and not the tools that determine the success of online delivery, and Inspira's (2020) case study of a university's switch to new online platforms indicate that any shift should be done slowly, particularly regarding new assessment practices – something obviously impossible during the pandemic. These findings are reinforced by a large review study of online learning by Tallent-Runnels *et al.* (2006), in which an examination of 76 articles on online learning unsurprisingly found that "students in well-designed and well-implemented online courses learned significantly more, and more effectively, than those in online courses where teaching and learning activities were not carefully planned and where the delivery and accessibility were impeded by technology problems" (116). This review also found that asynchronous communication methods facilitated in-depth communication (albeit not exceeding that of traditional classes), that students enjoyed moving at their own pace, that learning outcomes were generally the same as in-person courses, but that students who were trained in computers already were more likely to be satisfied with online learning. The key problems that Tallent-Runnels *et al.* (2006) highlighted at that time were a lack of technical support, policies or guidelines for staff or students; more significantly given the sudden onset of ERT from COVID-19, they also found that it was not sophisticated enough to merely move text-based courses to the internet but that online learning demanded extensive pedagogical planning.

The latter point echoes the primary "myth" of online delivery pointed out by Li and Atkins (2005): namely that "Traditional courses can be copied to online learning" (52). Some important realities they stress are that the shift in modality demands high motivation and self-discipline for success, and that student commitment and persistence are key. However, despite the benefit of flexibility, the workload for everyone is much higher (see also Allen and Seaman 2013; Tomei 2006); we can postulate that ERT is even more so. Barrett (2010) raises the issue that online communities tend to be more diverse (which may not be the case when they are forced online from live classes, of course) and that teachers need to update skills, practices and strategies to be effective online (which in the case of ERT there was little time to do).

It is also important to keep in mind the issue that Cloonan *et al.* (2014) foreground, which is that merely having the technology or hardware does not in and of itself excuse institutions from focusing on proper pedagogical or organizational practices in online learning. Garrett (2019) flags the fact that online delivery is inadequate to whole degree delivery, particularly for international students, and it is no match for live interaction (travel, immersion and networking). Timmis *et al.* (2015) highlight that online assessment particularly risks major issues of social exclusion, new kinds of digital dividedness, and ethics around big data and learning analytics. They recommend using interdisciplinary design teams to research more participatory approaches.

These concerns will be echoed below in the context of the COVID-19 ERT context, but first we would like to emphasize the challenge of student engagement in all forms of online learning.

2.2 Engagement

Summers *et al.* (2020) found clear evidence in their case study of a UK university that initial engagement is a key factor in continued engagement and student success, while Markowitz (2020) reports that thanks to COVID-19, students in general are struggling to stay motivated, so there is certainly a clear challenge for all teachers in this era.

Vermetten *et al.* (2002) stress that "Learning environment and individual learning processes cannot be treated as if they exist separately from each other. They both influence each other in a constant interplay" (264), which is a key problem when there is a sudden onset of ERT and these cannot be adequately controlled. Engagement should be active in terms of asking questions or working collaboratively with others (Ahfeldt *et al.*, 2005) thus interaction is key at all levels (following Koljatic & Kuh 2001), but this is also a challenge under emergency measures. Indeed, Bryson and Hand (2007) find that student engagement ranges from disengaged to engaged, and each student may have different levels at different times. Therefore, multi-faceted engagement activities are required. Teachers are indeed key, as was noted for general online education above.

Dumford and Miller (2018) found that the greater the number of online courses, the less collaborative learning, interaction, and discussion took place generally; further, there was lower exposure to effective teaching and the interactions that did take place were of lower quality than in live classes. Again, the online modality is unique, and should be treated as such: design and support are key factors, as is adaptation of certain activities that require content knowledge or interaction, particularly in the realm of assessment (as per Shuey, 2002). As we have found here at UNNC, there remain questions on the ease of cheating online, but also on the limitations of formative feedback during the learning process.

Parry *et al.* (2020) suggest ways of using mobile technology (such as social media and augmented reality) as ways to increase student engagement, particularly in large class settings. Such resources provide a student platform for expression, though a key point made by Morgan (2020) provides a segue into our discussion of ERT: "just because new students (especially undergraduate) may be 'social' digital natives, they are not necessarily ‘learning’ digital natives” (9). The shift can therefore also be a problematic one even for those who are familiar with the hardware, but generally use it in different ways.

2.3 Emergency Remote Teaching

Morgan (2020) also makes the key observation that the main principle COVID-19 has taught us is that we need to be prepared for further uncertainty. Indeed, flexibility and adaptability in teaching, along with the importance of communication, is stressed by Sandars *et al.* (2020) in ERT medical subjects. In the same field, Fawns *et al.* (2020) argue that part of the issue has to do with educators fundamentally misconstruing the metaphor: a course is not a material object, but a social event which is more like a live orchestra than a recording, and thus placing it online is not a simple task of knowledge transfer but also involves consideration of interaction patterns. Jacobs (2020) provides some insight into why ERT is not simply a matter of putting our materials online: proper digital courses operate synchronously, and require years of design to go well. In the present context, neither teachers nor students have signed up for wholly distance learning, and indeed proper distance learning is much more fixed in the sense that it is not going to revert at any time to face-to-face, unlike the situation in which ERT finds itself. Akin to this point, Mackie (2020) stresses that Higher Education in general has been moving from a knowledge focus to a skills focus, and this therefore makes the ERT online move more difficult; this shift ties in with the issues of engagement already discussed with the suggestion that strong initial feedback is the key.

In terms of the results of ERT, some surveys have found that faculty have developed a more positive attitude towards online learning, but there are problems with readiness, student experience, access and how universities can address these gaps (Fierce Education Staff, 2020). This same report suggests that to succeed, institutions need to adopt a centralized online learning hub, designed properly and using peer-to-peer collaboration. Most faculty in that survey prioritized engagement and stated that the top challenge was keeping students engaged. To do so, small group assignments, self-evaluation, real-world relevance and personal contacts were found to be the best means.

Unfortunately, concern is simultaneously emerging that far from being a panacea for the problems caused by COVID-19, the effectiveness of online learning itself is coming into question (Herman, 2020). Most institutions and observers nevertheless believe that blended learning is the future of education and that we are unlikely to ever go back to a pre-COVID-19 model. A case study of chemistry curriculum ERT (Jeffery & Bauer 2020) revealed that lectures changed little, but lab sessions “changed dramatically from decision-rich first-person experiences to suboptimal passive observation” (2472). Communication networks, which are key to all HE, were lost and led to poorer student comprehension, motivation, and engagement in general. The authors remind us that unlike traditional kinds of online learning, here the participants were all coerced instead of choosing the modality, but essentially all of the problems previously noted in the online learning literature were also encountered here, but amplified.

Some findings from the world of EFL (English as a Foreign Language) were slightly more optimistic, with one from a major university in Thailand (Todd 2020) finding that teachers were able to adapt to many of the first problems they encountered, though they remain wary of the value of online teaching. Major issues were with time spent on communication and checking assignments, and suitability of activities, student comprehension and preparing stimulating activities. Particularly beneficial in that context, though, were the range of people offering solutions, from peers to support staff and even students themselves. Perhaps most positive was that the administration of that institution was supporting, sympathetic and non-judgmental. A study of four Sino-foreign universities (Davies *et al.* 2020) which included UNNC emphasized the importance of course design with support features to assist independent and autonomous learning, while noting that asynchronous delivery decreases interaction and, as above, plagiarism was a key issue in this sudden ERT. Ultimately, sharing good practice internally and externally at all levels is key, and so the next sections will explore what we have found from our student and staff data.

3 Results

This section moves through some of the more interesting findings in the Student Survey, followed by the Staff Survey. Some of our qualitative findings from staff interviews and experience are also used to support what we believe to be the reasons behind some of the data, filling in the blanks as it were.

3.1 Student Online Learning

The student survey received quite a robust response rate, with 1346 students or 17.3% of total registered students. Of these, 81% were UG students and 19% were PG students, and 71% had returned to campus. The overall satisfaction rate to University support indicated that 51% of the respondents were generally satisfied (39%) or very satisfied (12%), 23% were neutral and 26% were dissatisfied with the support from UNNC. In terms of the overall online learning experience, 44% of the respondents were generally satisfied (35%) or very satisfied (9%), while 31% were generally dissatisfied (24%) or very dissatisfied (7%). Somewhat hearteningly, 90% of the respondents considered that online learning had improved between March 2020 and June 2020. 72% of the respondents said that COVID-19 had challenged their studies to different degrees (Critical challenge 13%; Many challenges 33%; Moderate challenge 26%).

Some interesting contrasts showed up in the data. Despite 56% not being satisfied with the online learning experience, few responded positively to returning to face-to-face teaching (36%). In addition, and in contrast to the digital natives presumption in the literature, half our students did not see online learning as being effective in assisting their learning.

The noted improvements in online learning indicates that either (1) quality did improve from the early part of the semester while more academics used the standardised tools provided by UNNC; or (2) students' initial expectation on online learning became aligned with the University's vision and response.

It is worth noting that students did have the technological skills to engage in online learning (87%), but many had not experienced online learning previously (53%) and 18% had no interest in engaging through online learning. The 47% that had experience in MOOCs (Massive Online Open Courses) or other online courses would have particular expectations of how they would be set up, meaning that the sudden onset of ERT would be at a definite disadvantage in terms of organization. Indeed, in this case the social or human contact seems to be the predominant "missing" factor from online learning, as previous studies also emphasize. We believe that students were relatively more satisfied with accessing and using Moodle (67%) because of its familiarity (and thus the Feedback, Forums and Quiz functions were well used), and that other tools quickly adopted were not widely employed by academics in the ERT due to time constraints. One exception was the simple synchronous videoconferencing platform Zoom, which enjoyed a 63% satisfaction rate.

The students tended to prefer a learning approach with elements of offline interactions as 47% preferred offline learning, 44% chose blended online and offline learning, while only 9% went for online learning.

In terms of effectiveness of online learning, students rated the following as the top 3:

1. Flexible time of study
2. Flexible location of study
3. Recorded lecture sessions

The least effective aspect of online learning was online tests and assessments.

Despite the fact that students believed the recording of sessions was effective, they still reported lack of social or learning interactions as the major challenge in online learning. Specifically, the top three factors rated by students were:

1. The lack of an engaging in-class experience
2. Missing social connections with other students
3. Missing face-to-face interaction with faculty during class

Some of the suggestions for improvements to online learning were improved access to digital materials; better responsiveness from module convenors/tutors; and better assistance with technology to support online learning. Qualitative comments indicate that the quality of online courses needs further improvement (particularly Powerpoint slides and video); in many cases there was a lack of communication with tutor; there were some concerns over unassessed homework (especially forums); and perennial concerns with technical problems, both actualized and potential.

Overall, a small majority of our students (59%) seemed undeterred by COVID-19 and still wanted to study abroad, but this may also relate to desire for tangible, physically present interactions as above. This finding reinforces that the students are not just attending university to learn, but to socially and intellectually engage in person.

3.2 Staff Online Delivery

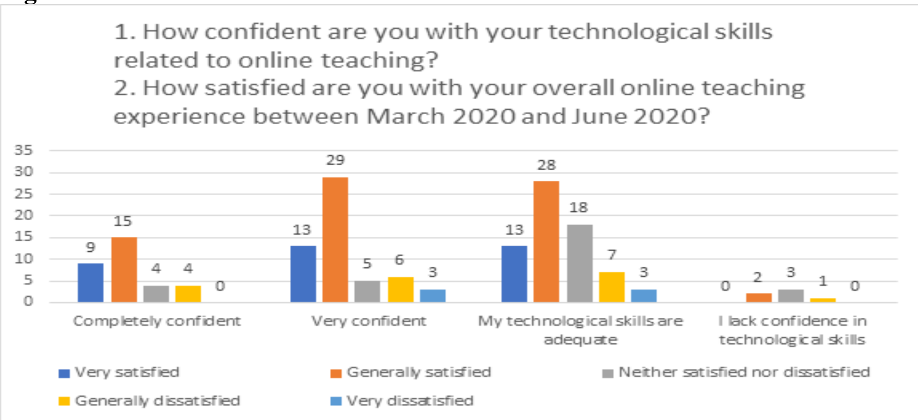
There were 317 responses to a range of issues including both quantitative and qualitative feedback, accounting for 35.5% of total staff population. 57% were academic staff and 43% were academic support and professional services staff, and of these, 67% were on-site at the time of the survey.

In terms of university support, 65% of the respondents were generally satisfied (40%) or very satisfied (25%) which contrasts favourably with the student satisfaction rate.

The overall online teaching experience was better at the higher end to that of the student data, with 63% of the respondents generally satisfied (41%) or very satisfied (22%), and only 16% generally dissatisfied (12%) or very dissatisfied (4%) with the overall online teaching experience. Also hearteningly, 85% of the respondents considered that the online teaching had improved compared with when it was first launched. Unsurprisingly, 78% of the respondents said that COVID-19 had challenged their work to different degrees (Critical challenge 16%; Many challenges 42% ; Moderate challenge 20%).

One key takeaway from the staff data was that it appeared many overestimated their technological skills. Table 1 below shows the interaction between confidence in technology and satisfaction with the online teaching experience:

Figure 1: Tech skills and satisfaction



As can be seen here, 96% (195) of the respondents considered that they have adequate (45%) or confident (51%) level of technological skills related to online teaching and this appears to be assisting with overall satisfaction rates; however, the qualitative data from staff training, interviews and survey responses show a large number of places where basic skills in some of the tools is lacking.

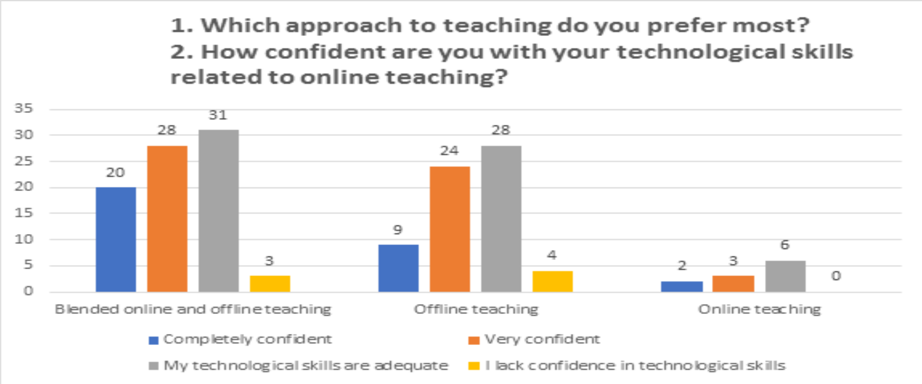
Like students, staff also tended to prefer a teaching approach with elements of offline interactions as 51% of the staff preferred blended online and offline teaching, 42% preferred offline teaching while only 7% preferred online teaching.

In terms of effectiveness, staff listed the following top 3 aspects of online teaching:

1. Flexible location of working
2. Flexible time of working
3. Interactive online sessions.

Similar with student feedback, the least effective aspect of online teaching was also online tests and assessments; however, the key contrast here is with number 3, in which students (who are predominantly second language speakers) believed recorded material to be more effective for learning, while staff considered the interactive sessions more so. Some of the disconnect there likely has to do with where staff were located, since those outside of China also had to deal with differences in time zones, but also indicates that many staff were unaware of student expectations for engagement. As above, we can align teachers' preferred approaches to their confidence in online technological skills and see that despite claiming to be confident with these skills very few prefer online teaching:

Figure 2: Tech skills and preferred modality



The greatest challenges that teachers reported for adaptation to the online approach of teaching was having limited information on students' progresses and expectations, and in particular the following were noted as the top 3 challenges:

1. Being unaware whether students are succeeding online
2. Encountering changing expectations from students
3. Having to make further adjustments to course content and assessment methods

Like students, teachers were concerned with improved access to digital materials, but they also wished for guidance for students on how to participate in online classes. For themselves, despite the high confidence in their technology skilled seen above, teachers wanted better training and resources on how to quickly transition to online teaching. Qualitative comments expressed similar problems with teaching tools and internet problems, focusing on Zoom and Moodle and the necessity of using a VPN for a number of types of access. Further, many felt that there should be an online teaching guide from UNNC. As also mentioned, they found it difficult to monitor student engagement, and there were a number of problems with online assessment. Finally, many expressed that blended delivery leads to duplicated work, and indeed that continues to be the case as we still have a number of students off-site and needing online support going forward.

4 Discussion

As Jeffery and Bauer (2020) found in their study, many of the problems initially identified for online learning in general were present in our shift to ERT and continue to be so as we move to more blended teaching. We suggest that these problems may be somewhat exacerbated by the fact that instructors tend to overestimate their own skills with new technologies and platforms while also assuming that students, as so-called digital natives, should have an easier time transitioning to new learning technologies. Luckily, given a reasonably affluent student population with access to a strong set of mobile data networks, UNNC did not have to contend with what the WHO (2021) has highlighted in terms of unequal or even non-existent ability to receive materials and connect remotely, a phenomenon that Timmis *et al.* (2015) also warned about. We have also found that there were considerably higher challenges in shifting skills-based curricula online (as per Mackie 2020; Jeffery and Bauer 2020, and explicated in Gill *et al.* forthcoming for UNNC).

The suggested solution, fittingly enough, is that more education is required on the part of instructors to ensure that their beliefs in technological prowess can match their practice; further, students need to have their expectations for online engagement made explicit and supported by the institution. Again, following the existing findings on online learning in general, the key is clear communication made more vital by an uncertain set of circumstances which created a forced community of online learners and teachers.

5 Conclusion

This paper set out to explore the features of online learning and student engagement which were most crucial to the emergency remote teaching and then subsequent blended learning models required due to the COVID-19 crisis in the particular context of a Sino-British university in mainland China. We found that both students and teachers preferred in-person or blended models to purely online learning, so as to take advantage of the flexibilities of online delivery in terms of time and space; however, while instructors also considered the online format to be positive in terms of interaction, students as social digital natives did not. Ultimately, although all of the participants seemed to appreciate ERT for precisely the stopgap measure that it was, in order to move forward into the expected blended model a much more substantial consideration of good pedagogical practice and material design by cross-disciplinary campus teams would be best practice.

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Student Mentorship Programmes: Students as the Real Teachers?

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Abstract

Purpose – The Sino-foreign higher education institutions (SfHEIs) in the People's Republic of China (PRC) grew as an innovative response to a (then) pressing PRC education problem — providing a sufficiently high quality and quantity of higher education (HE) opportunities. These SFHEIs have also been centres of innovation, with many exciting initiatives being developed to address the ongoing challenges that SfHEIs have faced. This paper looks at a key element of many such initiatives — that of students as change agents (SACA), where students themselves become the agents to make the changes they seek. In this instance, a recent Student Mentorship Programme (SMP) is explored.

Design/methodology/approach – The paper is structured around a report on a partially student-led initiative at the University of Nottingham Ningbo China (UNNC), the first SfHEI in the PRC. Identifying several challenges and opportunities surrounding undergraduate student learning, and the potential for senior undergraduate students to gain teaching experience, a small group of proactive final year Computer Science (CS) students collaborated with CS staff to create an SMP, whereby senior students would volunteer to support more junior students in their learning. This involved supporting computer lab sessions, and also offering advice on general study strategy. They were also able to serve as an additional line of communication between students and the faculty, providing both feedback and advice to students and staff.

Findings – This report highlights a number of advantages to SACA initiatives in general, and this SMP in particular. The mentored students reported increased satisfaction; the relevant teachers received additional feedback and support for their teaching; and the mentoring students also gained valuable insight into teaching as a potential future career direction. An additional gain was the newfound ability to provide teaching-related comments in the mentors' graduate study applications. The overall experience resonated with an earlier experience of one of the authors, a decade earlier, at another SfHEI (United International College, UIC), where a spectrum of four types of Teaching Assistants (professional; graduate students; foreign language; and undergraduate students) were deployed to support UIC's teaching. These two experiences are contrasted, and recommendations for best practice identified.

Originality/value/implications – The COVID-19 situation has again emphasized the need for adaptability in education and in other fields. The findings and recommendations in this paper, especially in the context of peer support and peer learning, will be of interest to educators seeking more opportunities for student feedback, and seeking to engage their students more deeply in the learning journey.

Keywords: COVID-19, mentorship, peer learning, Students As Change Agents (SACA), teaching support.

1 Introduction

The COVID-19 pandemic caused disruption to many higher education (HE) institutions (HEIs), resulting in changes and innovations to their teaching and learning (T&L) practice (Lau et al., 2020), including in the provision of feedback to students (Gill et al., 2020; N.D.). This has again emphasised the need for HEIs to be flexible, adaptable, and agile (Towey, Walker, & Ng, 2018; 2019).

University of Nottingham Ningbo China (UNNC) was the first Sino-foreign HEI (SfHEI), created in 2004 as a partnership between University of Nottingham and the Wan Li Education Group, established the first SfHEI, UNNC. United International College (UIC) was founded in 2005 by Beijing Normal University and Hong Kong Baptist University. UIC was the first "SfHEI" between the People's Republic of China (PRC) and Hong Kong. Both UNNC and UIC are English Medium of Instruction (EMI) institutions.

A recent initiative at UNNC, the Student Mentorship Programme (SMP), was a UNNC collaboration between staff and students, whereby more senior students would volunteer to provide support (academic and other) to more junior students. The SMP ran as a pilot in the second semester of the 2018-2019 academic year, and was in the process of being expanded the following year when it was impacted by the COVID-19 pandemic and subsequent lockdown in the PRC (Gollwitzer et al., 2020).

This paper reports on some of the initial reflections and findings as part of the on-going development of the SMP. Some of these findings resonate and relate to an earlier study we conducted at UIC (Chen, 2010), prompting a number of further reflections that we share here.

2 Background

As discussed previously (Towey 2014; 2016), China's economic growth based on a manufacturing industry boom needed to change to a services-oriented economy, which required some restructuring of the PRC HE landscape (Zhao, 1998; Li et al., 2012). One aspect of these changes was the emergence of the SfHEIs (Lixu, 2004). SfHEIs appeared as an innovative solution to the PRC need to provide more HE opportunity, and, as well as thus being innovations, they are also often themselves been hosts to innovative projects (Towey, 2014). Two SfHEIs, UIC and UNNC, are the settings for the studies discussed in this paper.

The distinction between native and non-native English speakers represents a paradox for many researchers in applied linguistics (Medgyes, 1994; Moussu & Llurda, 2008), who may argue that the dichotomy is not "linguistically acceptable," but is nonetheless "socially present." The definition of *nativeness* is elusive, especially in the case of speakers of more than one language, but there is a clear reported preference in many contexts for the *native speaker* (Moussu & Llurda, 2008). The situation is further complicated (or confused) by the many varieties of English in the world (Kachru, 1994); the fact that the majority of communication through English does not involve native speakers (Smith, 1988; Smith & Nelson, 1985; Smith & Rafiqzad, 1979); and the fact that research indicates that the most intelligible English speakers are not the native speakers (Smith & Rafiqzad, 1979).

Among the many varieties of English, although *Chinese English* does not yet have the degree of championing that some other regional varieties may have — e.g., Indian English (Kachru & Nelson, 2006) — there is increasing awareness of its legitimacy (Xu, 2010). One reason for the choice of the UIC TESL (Teaching English as a Second Language) to be TESL rather than TEFL (Teaching English as a Foreign Language) was the hope that English may become a second language in China (Jiang, 2003). In such a case, the demand for Chinese people as English teachers should increase. At the very least, demand for lower ranking academic staff (including teaching assistants, TAs) with appropriate skills, but without necessarily being native speakers of one of the canonical varieties of English (Kachru, 1994), should certainly increase. This motivated our earlier study (Chen, 2010) investigating the effectiveness of different types of TAs, where native English was one of the distinguishing characteristics.

HE classroom interactions and expectations have been changing significantly, including the appearance of more student-centred approaches (King, 1993; McWilliam, 2009; O'Grady et al., 2014). The inclusion of more student input has not been confined only to feedback on teaching (Nicol, Thomson, & Breslin, 2014; Xie, Towey, & Jing, 2014), but can be seen in programmes such as the Students as Change Agents (SACA) (Dunne & Zandstra, 2011), which explicitly include students in the development of their own education pathways. The 2019 UNNC SMP was started partly as a SACA-style initiative.

3 UNNC Student Mentorship Programme (SMP)

UNNC runs a software engineering team project (SETP) class for penultimate year undergraduate computer science (CS) students (Towey, 2016; Towey & Pike, 2021). The SETPs are completed by teams of five to seven students, who work on software engineering problems over the course of a year, under the supervision of a member of staff. As part of the support for the SETPs, the coordinator (an author of this paper, Towey) provides weekly workshops, lectures, and other activates (Towey, 2015). One very popular activity is the annual Seniors Consultation session, when previous SETP participants join the SETP cohort for an experience-sharing and consultation. Feedback from some senior student participants highlighted that they enjoyed this opportunity to contribute to their juniors' experience, and that they would like more such opportunities (Dybå, Maiden, & Glass, 2014). This led, in 2019, to the first (pilot) trial of the UNNC CS student mentorship programme (SMP).

Some of the original objectives and content of the SMP included:

- Provision of training to introduce basic teaching, coaching, ethical, and pastoral principles to equip the student mentors to engage junior students, through the CS classes (including labs, seminars, and tutorials).
- The student mentors were to serve as role models to the junior students (having already recently taken the same classes).
- They were expected to have closer relationships with the junior students than was possible between teachers and students.
- They were to be relatively free in how they mentored, without obligations, for example, to always attend certain classes, or labs.

- The student mentors were expected to gain leadership experience, and experience as potential future tutors (something that can be important for some postgraduate study programmes).
- They would also represent a new stakeholder class in the UNNC CS T&L experience, feeding into feedback mechanisms at multiple levels.

As with any new initiative, educational or other, our pilot run was expected to have challenges (Ertimer, 1999; Fullan, 2007), which it did (and which are discussed in the Discussion section). Nevertheless, there was, overall, a very positive impact, with feedback from the student mentors, mentees, and other relevant stakeholders all very good. Based on this, we planned to expand the SMP over the following year, the 2019-2020 academic year.

The COVID-19 situation in the PRC caused a lot of disruption, at UNNC and elsewhere (Gill et al., 2020; N.D.). The SMP was also disrupted. Some of our observations on the SMP from its initial pilot, up to now, allowed us to identify common themes with our earlier study at UIC (Chen, 2010). Although both the SMP and our study of the related issues continue, the next section presents some key initial points.

3 Mentorship and Teaching Assistance

Across both the UIC study and the UNNC SMP, the main actors could be considered to fall into the following categories:

3.1 UNNC Student Mentors (SMs)

Since 2019, UNNC CS has been exploring and expanding the SMP, though which senior CS student volunteers are invited to join and offer support to the more junior CS students. These student mentors (SMs) do not receive remuneration.

3.2 Native English-speaking TAs (NES TAs)

Since its foundation, UIC employed a number of native English speakers (NES) to act as English Language TAs. Usually, these NES TAs (later labelled *foreign interns*) were recent graduates with a Bachelor's degree, often in a field unrelated to language or education. In the year of the UIC study (Chen, 2010), the TESL Department had the use of eighteen NES TAs: Three of these TAs majored in English or Language Studies; five in Politics; four in Sociology; two in History; two in Philosophy; and one each in Business and Anthropology. Fourteen of these TAs had previous experience tutoring (the highest number since UIC's founding in 2005), and one had received professional training for tutoring.

Bauer has suggested that NES TAs may face more challenges in the HE context, compared with local TAs (Bauer, 1996). The different cultural and social backgrounds, and probable lack of familiarity with the Chinese teaching and learning settings may lead to such challenges (Luo, Bellows, & Grady, 2000).

3.3 Professional TESL TAs

From 2008, the TESL Department had also been able to employ TAs with a background related to TESL (usually holding a Master's degree in Linguistics or Teaching Methodology, and having some relevant work experience). In the year of the UIC study (Chen, 2010), there were two full-time TESL TAs. Both were Chinese nationals with overseas and tutoring experience, with one also having received professional training for tutoring.

3.4 Student TAs (STAs)

Since 2008, when PRC visa restrictions reduced the availability of NES TAs (AFP, 2008; Baker 2008), TESL had been appointing senior TESL students as Student TAs (STAs) to help the more junior students. Initially, these STAs received a small honorarium for their TA work. At the time of the UIC study (Chen, 2010), TESL had recruited 21 STAs, five of whom had previous experience tutoring, but none had received professional tutoring training.

It should also be noted that, in contrast to the UNNC SMs, the TESL STAs, in addition to their honorarium, may have had the additional incentive of their TA work contributing to practical experience related to their TESL degree studies. The UNNC SMs, as CS majors, had less obvious practical connections for their mentoring efforts.

It has been reported that STAs are often employed by professors or supervisors to help with the classes that they have already in their previous academic study. However, due to their limited knowledge of the academic content, STAs may often be considered as unreliable resources in content-based class tutoring (Liao, 2009). On the other hand, STAs are reportedly responsible with their duties, and can help to build an effective connection between teachers and (Liao, 2009).

3.5 Graduate Student TAs (GTAs)

In the year of the UIC study (Chen, 2010), a top-scoring graduate of the 2006–2010 TESL cohort was working on her MPhil degree (by research), as part of the conditions for which she provided some Graduate TA (GTA) support to TESL. This student, as well as being a graduate from TESL (and therefore intimately familiar with the programme) was also one of the original STAs in 2008. However, she had not received any professional tutoring training.

UNNC CS also employs GTAs, all of whom are PhD students. The UNNC GTAs are paid an hourly stipend for their GTA work.

3.6 Class Teacher

In any situation of TA or SM involvement, the relevant class teacher was naturally consulted and included in the arrangements. The involvement of the teacher varied with the nature of the TA/SM: the professional TESL TAs, for example, had significant guidance from the teacher; the SMs, in contrast, had very little.

3.7 SM/TA Coordinator

In addition to the class teacher involvement, there was also an overseeing coordination role. The overall coordination of all TESL TA activity was done by the then department head, an author of this paper: Towey. Likewise, Towey was also involved in the establishment and coordination of the UNNC SMP. The UNNC SMP students, unlike the TESL TAs, had far less engagement with the coordinator, with most such communication surrounding feedback or advice, rather than explicit instructions.

4 Discussion & Conclusion

An expectation common for all TAs/SMs was to augment the communication between students and instructor (and coordinator). This appeared to happen in all cases.

In the UIC study, it was expected that STAs, professional TESL TAs, and the GTA would all (1) help the students with technical (course-related) questions; (2) Provide possible Chinese language support to help student comprehension; and (3) be a role-model for students (either as current students or future graduates). It was also expected that the TESL TAs and GTA would be approached very often for career advice. These things all seemed to happen.

Only the NES TAs were explicitly expected to improve UIC TESL student English production skills (speaking, presentation, and writing), and only they were explicitly expected to become friends with their assigned students, and interact in social as well as academic surroundings. It was also expected that they would help most with showing students different approaches for research (e.g. using the library, databases, etc.) — which is what the UNNC SMs were anticipated to do.

The UIC STAs were the only UIC group explicitly expected to also help students make a transition to college life. The UNNC academic structure differs from UIC in that, although both are 4-year degrees, the UNNC first year is conducted independently of the major — spent in a sort of year of English enhancement and UK-Education preparation. This means that the students whom the UNNC SMs interacted with, while possibly in the first year of CS classes, were not in their first year at UNNC.

The UIC GTA was expected to be the TA most approached (overall) by students, and the professional TESL TAs were the only group expected to assist the instructor in grading/marking, and in the provision of formal, course-oriented tutorials. This, again, is an area where UIC and UNNC differ: UNNC has no professional TA structure (no full-time teaching assistants), and has much stricter regulations over what a GTA can do regarding marking.

It was noted, in both UIC and UNNC, that how the TAs/SMs were engaged with evolved over time. Some of these changes could be correlated to the students' changing levels and nature of coursework.

Towey (2015) reported on a failed attempt to flip the classroom, as part of his reflection on which he noted how he learned things from his students. The various TA structures and SMP initiative explicitly aim to support student learning, but also aim to provide feedback to the various stakeholders (including teachers): this is also an opportunity for teachers to learn.

Given the many different motivations and aims related to the different TA/SM provisions (and investigation), there are many interesting aspects deserving of deeper investigation and analysis, which are ongoing, and we look forward to reporting on in our future work.

Acknowledgements

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Multilevel Challenges in Learning Design: An Investigation of Novice Learning Designer Teams

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Abstract
Purpose – The overarching problem for the present study is to address the need for courses that provide novice learning designers (LDers) with the necessary conceptual understanding as well as the professional and technical skills to undertake the full spectrum of learning design (LD) decisions from course to task and resource levels to achieve coherence, alignment and effectiveness with regard to identified learning outcome goals for targeted learner communities. Two key scaffolding supports were provided for the students' LD process: (1) a 7-step LD model centering around a Learning Design Triangle (LDT) framework that includes the design of learning analytics (LA) and feedback and evaluation to highlight LD as an iterative process of improvement, and (2) a technology platform, the Learning Design Studio (LDS), that students can use to develop their evolving designs following the 7-step model.
Design/ Methodology/ Approach – The case study reported in this paper was carried out in the context of a Master level course on Learning Design and Technology that aimed to provide a comprehensive introduction to the multiple levels of LD from course to resource levels. Course participants were novice LDers with diverse academic and professional backgrounds. They were required to work in teams to design a mini-course. At the end of the course, Students had to submit their LDs in three representational formats: a course outline, LD documentation on the LDS, and their course design implemented on the Moodle learning management system (LMS).
Findings – The findings reveal challenges encountered by novice LDers at different design junctures and the diverse trajectories experienced by different design teams. The use of the conceptual and technological LD tools and the need to progressively develop multiple representational formats in tandem for the same mini-course prompted the novice LDers to articulate their pedagogical reasoning during the LD process, heightening their awareness of the alignment (or lack of) of their LD at different design levels.
Originality/ Value/ implications – The study also shows the value of the LDT framework and LDS in supporting the professional development of novice LDers. Implications for theory and practice in the professional development of novice learning designers are discussed.

Keywords: learning design, teacher professional development, pedagogical innovations, learning design triangle

1. Introduction

1.1 The Professional Work of Learning Designers

Learning design (LD) is an emerging field attracting engagement of researchers and practitioners from multiple disciplines. There are different descriptions for the focal concern of LD, reflecting the disciplinary/professional interests and backgrounds of those involved. Those involved in LD from the perspective of designing tools and resources to support learning (Agostinho, Bennett, Lockyer, & Harper, 2011) are often instructional designers or work closely with them. Teachers, teacher educators, and educational researchers often perceive learning design as a productive mode of teacher learning for transformations in pedagogical practice (Mor, Ferguson, & Wasson, 2015). We consider all of these professional roles as learning designers (LDers).

A review of literature and prevalent practices shows that instructional designers play a more decisive role in creating learning artefacts, particularly when it involves the use of new technologies. Teachers are more responsible for the LD decisions at higher pedagogical levels such as pedagogical philosophy and pedagogical approaches (Goodyear, 2005) which heavily influence the design of educational settings, such as the technology integration at the task and resource levels. With the increasing prevalence and accessibility of digital tools and online resources, many teachers who do not have the luxury of engaging the support of educational technology specialists in their course design work are able to integrate their use in teaching and learning (Charlton, Magoulas, & Laurillard, 2012). This does not only blur the distinction between LD and instructional design, but also creates a need for LD professional development to include the full range of LD activities from course level down to the level of individual learning resources.

1.2 Complexities in LD—the Need for Alignment across Multiple Levels

Learning design (LD) is complex and requires expertise in decision making at multiple levels, from overall course design, to task sequencing within course topics, to the design of individual learning tasks, to the design of specific resources. (Goodyear, 2005) proposes a multilevel pedagogical framework that deconstructs the complexity of LD into four layers: pedagogical philosophy, high-level pedagogy, pedagogical strategy, and pedagogical tactics.

The top or most macro level of design decision is at the pedagogical philosophy level, which is determined by the designer's belief about how people learn, and what are the most important goals of education. These are deeply ingrained as "default" beliefs, influencing all other connected levels of design, often without the LDer having to make deliberate design decisions. Pedagogical approach influences decisions about structuring of the overall course design, for example problem-based learning, inquiry-based learning, experiential learning. Pedagogical approach decisions influence the overall sequencing of the targeted learning outcomes to be achieved, and hence provide a framework for the sequencing of the curriculum topics. Pedagogical strategy addresses design decisions involving the nature and sequence of learning tasks to be provided to the learners to achieve the learning outcome objectives targeted by a particular curriculum topic. "Predict-observe-explain" is an example of a pedagogical strategy, which can introduce an important and often misunderstood topic such at both learners and the teacher can be aware of the diversity of (mis)conceptions held by the course participants. Pedagogical tactics guide the design decisions at the task level. For example, in giving a quiz to students, pedagogical tactics include whether multiple attempts are allowed, or which type of motivators are adopted. These hierarchically nested levels of design decision are common in many fields of design, and need to mutually consistent and aligned for the design to be coherent (Alexander, 1977, 1979).

Based on the multilevel framework of pedagogical decision hierarchy for LD described above, Law and Liang (2020) put forward the 7-step LD model centering on a Learning Design Triangle (LDT) framework to guide the LD process, which includes the design of feedback and alignment check to ensure coherence and consistency.

1.3 Need for a Commonly Adopted Design Language and Tools for Connected Levels of LD

Design professionals need a commonly adopted design language to communicate design ideas and decisions accurately and to facilitate collaboration. A well-defined LD language will help to minimize the gap between guiding design principles and the development of detailed learning tasks for implementation (Conole, Dyke, Oliver, & Seale, 2004; Persico & Pozzi, 2015). (Law, Li, Herrera, Chan, & Pong, 2017) put forward a basic LD language comprising a system of vocabularies to refer to the different levels of design decisions and a learning task taxonomy that helps LDers to visualize the proportion of time that learners spend across four broad experience categories—directed learning, exploratory learning, productive learning, and reflective learning—if implemented as designed. This LD language and task taxonomy has been adopted in the design of a digital LD tool, the Learning Design Studio (LDS). As the design parameters captured by LDS are already structured according to the LD language and task taxonomy, users are provided with a designer dashboard that visualizes interactively the key design features of their LD during the design process.

1.4 The Current State of Professional Preparation for Learning Designers

Courses on LD generally fall into two categories: those targeting teachers and others targeting instructional designers. LD courses for teachers generally focus on course level pedagogy, including the learning theories and design principles underpinning different pedagogical approaches, and descriptions of the main flow in terms of broad segments of learning activities. The more detailed levels of learning tasks and resources design are only touched upon briefly. On the other hand, LD courses for instructional designers have a strong focus on task sequences, tasks, and resources. Workshops and seminars of specific approaches and tools, which are based on the assumption that high-level decisions have been made and that the key foci is to design the specifics of learning task sequence and resources in the educational contexts. Courses that address the full hierarchy of design levels and their connections are rare. A challenge often observed in LD is the failure in explicit communication of design concepts from the pedagogical approach decisions to the design of learning tasks and resources (Conole et al., 2004). There is a need for a mechanism to minimize the gap between the intended theoretical concerns and the development of detailed learning tasks for implementation (Conole et al., 2004; Persico & Pozzi, 2015).

1.5 The Research Problem and Objectives

The overarching problem for the present study is to address the need for courses that provide novice LDers with the necessary conceptual understanding and the professional and technical skills to undertake the full spectrum of LD decisions from course to task and resource levels to achieve coherence, alignment and effectiveness regarding identified learning outcome goals for targeted learner communities. The goal of the study is to explore whether the LDT conceptual framework and the LDS tool could be effectively deployed to scaffold the learning of novice learning designers to develop adequate understanding and design skills to develop coherent and effective LDs throughout the multiple levels from course to task and resources design. Two specific research questions are addressed:

RQ1: What is/are most difficult concept(s) for novice LDers to grasp from the start to the completion of their course design sequence underpinned by the LDT framework? What challenges/misunderstandings, if any, do novice LDers have regarding the LD design language and task taxonomy adopted in LDT and LDS?

RQ2: Whether and how the novice LDers' conceptions changed during their course of study? What are the implications for the design of courses for novice LDers?

2. A Principled Multilevel Learning Design Language and Process Model

2.1 The Learning Design Triangle to Guide Course Level Design

The LDT framework (Figure 1) describes an operationalizable procedure that a LDer can follow to develop a "Sequence of curriculum topics and learning outcome goals to addressed in the overall course design" starting from a specification of the targeted Learning Outcomes (LOs) that should include disciplinary knowledge and skills as well as generic learning outcomes such as generic skills (e.g., communication, collaboration), metacognitive skills and non-cognitive outcomes. Bloom's Taxonomy is used for learning designers to systematically describe different stages of achievement in learners' cognitive domain (Chan, 2010).

The other two constructs—pedagogical approach (PA) and disciplinary practice (DP)— guide LDers to make top level pedagogical decisions for their overall course design. it has to be pointed out that the LDT framework assumes that the overarching pedagogical philosophy is broadly social constructivist in nature, prioritizing the adoption of inquiry-oriented pedagogical approaches.

After the specification of learning outcomes (LOs), the next step is to identify the "Disciplinary Practice" (DP)—the kind of subject matter (disciplinary) scenarios that would require the application of the identified learning outcomes. The third step is to select the Pedagogical Approach, which guides the development of main curriculum units that map the LOs with the unfolding DP scenario. The overall structure of a course based on the three constructs of the LDT is to be referred to as the sequence of *curriculum components* (CC). CC is defined as "assigned with a set of specific learning outcomes and embodies a coherent set of tasks constituting the identifiable steps in DP and PA" (Law & Liang, 2020). The design of the CCs determines whether there is constructive alignment among LOs, learning tasks, and assessments.

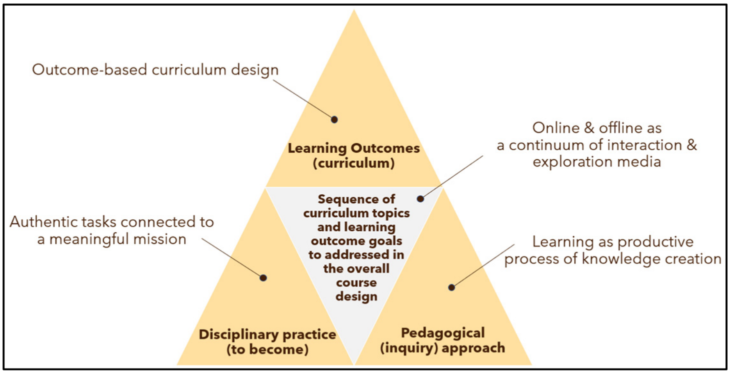

Figure 1. LDT framework

2.2 A Structured 7-step LD Process Model

Law and Liang (2020) have identified the necessity of having both the conceptual framework and design tool to provide a procedural guidance on how to construct a LD that moves from abstract pedagogical conceptualization to concrete tasks and settings for specific learner and learning contexts (Figure 2). The first four steps guide designers to structure their LDs from the course level all the way down to the details of task settings. The outcome-based approach (Biggs, 2012) for specifying the constructive alignment and backward design among the curriculum objectives, teaching/learning activities (TLAs), and assessment tasks is highlighted in the context of learning design across different levels.

In step 5, the LDer is prompted to identify learning analytics (LA) question that may help them understand the extent to which (1) learners have engaged in the learning tasks as designed, and (2) learners have achieved the targeted learning outcomes at different points in the learning process. This step helps the LDers to explore the LA results and visualizations available from the learning management system (LMS) they adopt, as well as the appropriateness and adequacy of the assessment included in the LD.

Steps 6 to 7 addresses the design of feedback, alignment check and course evaluation.

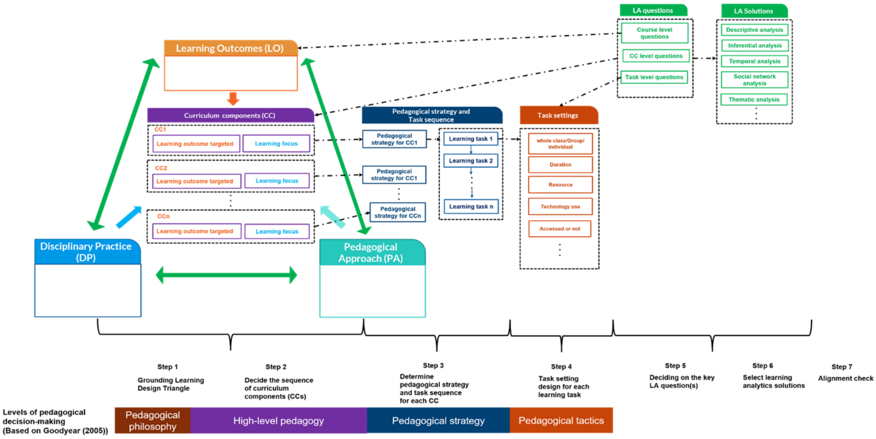

Figure 2. The 7-step LDT framework (Law & Liang, 2020)

2.3 A Multilevel Design Language and Formal Task Taxonomy

Both the LDT and LDS (Law et al., 2017) articulate a multilevel design language that connects the high-level course design, to increasingly finer design levels down to task, task settings and resources. There are 12 task types available in the LDS task taxonomy to facilitate the design of task sequences that match the pedagogical strategy (Figure 3).

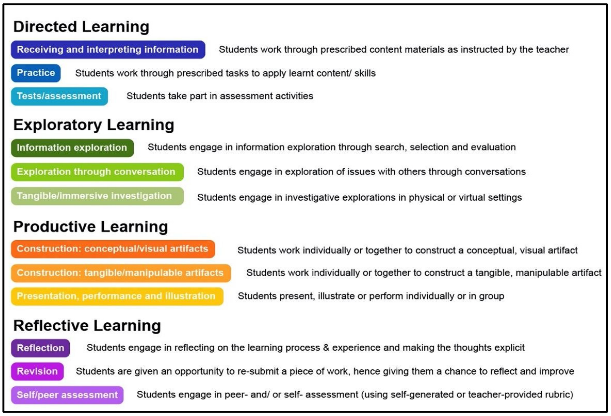

Figure 3. 12 task types in LDS (Law & Liang, 2020)

2.4 Learning Design Studio: A Principled Platform to Guide and Support LD Practice

Underpinned by the LDT framework, LDS (Figure 4) helps LDers to focus on each design level separately as well as to visualize the connections and the extent of alignment across different levels (Law & Liang, 2020). Figure 4 is a screencap of one of the user interfaces that shows the task sequence within a curriculum component.

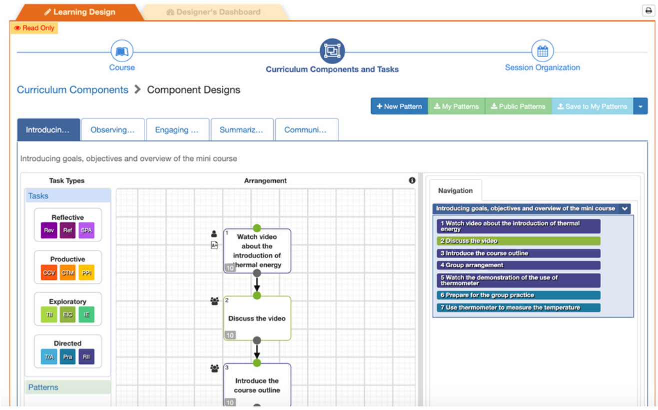

Figure 4. LDS

3. The Research Context

3.1 The Design of the Master Level Course on *Learning Design and Technology*

This study took place in a master-level course *Learning Design and Technology* during the academic year 2019-2020. This is an elective course for students interested in learning how to make effective uses of digital technology in diverse educational settings from primarily on-site, blended to fully online.

The course structure models the 7-steps in the LDT framework. Course participants are provided with the digital learning design tool – *Learning Design Studio* (LDS) to help them focus on each design level separately as well as to visualize the connections and the extent of alignment across levels.

The course adopts a social constructionist approach and assessment as learning is implemented throughout. Students were organized in "interprofessional" groups of 3 to 4 members with diverse experience and disciplinary backgrounds to work collaboratively on designing a mini-course of 3-4 “lessons”. Each group was assigned an education level (primary, secondary, or adult education) and disciplinary focus (STEM or humanities) for the mini-course to be designed by the group. Each group decided on the topic of their mini-course based on their interests/expertise.

Each week, students presented their design progress to make their learning visible, followed by comments, critiques, clarifications and the teacher's introduction of new concepts and resources for the next stage of design, and finishing with design studio time working in groups.

3.2 The Course Participants and Student Teams

The 19 Students taking this course in the 2019-2020 cohort were keen to learn but did not have a good understanding of the complexities in learning design, particularly in how to apply pedagogical theories in the design process. They often focused on designing interesting activities and engaging course materials and lost sight of the overall course coherence and higher-level learning outcomes.

Course participants held at least a bachelor’s degree in an academic discipline. Some were part-time students working as full-time K-12 teachers or learning designers in higher education institutions. Others are full-time students with a few years of work experience and interested in becoming teachers, instructional designers, or other careers as allied educational professions. Each group worked as an interdisciplinary team in which they develop learning design artefacts ranging from high level design documents such as a course outline, to a multilayered presentation of the learning design using LDS, to the implementation of the mini-course on Moodle.

4. Research Design and Methodology

4.1 Multiple Case Studies

Case study method was adopted for this research. In this study, three student teams were selected from a total of six groups purposively to cover the broadest spectrum of learning trajectories observed (see Table 1).

Table 1. Group profiles

Gp.	Members	Topic	Discipline	Grade
A	B.Y, K.I, J.W	Thermal insulation	STEM	Elementary level
B	O.W, Y.Y, Y.L	Social innovation for urban poverty	Humanity	Secondary level
C	L.K, X.Y, Y.L	Prepare for your first job	Humanity	Adult education

Group A designed a STEM mini-course for primary students. They demonstrated productive and iterative progress their course construction and achieved pedagogical alignment across different levels over time. They were able to identify and address the key LD issues explicitly for the learning outcomes they specified over the different phases of the design process.

Group B designed a humanity mini-course for secondary students. They had a clear specification of LOs at the beginning. Different from Group A, they had a comparatively vague understanding of the LDT and LDS, and their design process reveal a mechanical understanding of the framework and design process.

Group C designed a humanity mini-course for undergraduate students. Different from Groups A and B, this group failed to specify the LOs and jumped to the design of tasks at the beginning. Mid-way through the course, this group recognized that the “jumpstarting" was problematic and restarted their design work from step one in the LDT. Both Groups B and C were able to arrive at a more coherent design of task sequences and assessments when they gained a deeper understanding of the design framework and concepts as the course progressed.

4.2 Data Collection and Analysis

Two types of data were collected for this study. The first type comprises students’ progressive LD artefacts produced during the course of study. This includes (1) group design logs, (2) weekly group presentation slides, (3) LDs captured on the LDS platform, (4) the mini-courses implemented on Moodle, and (5) a course outline in document format. The second type of data comprises semi-structured group interviews.

Consent was sought from the course participants before they were used for research purposes.

A coding scheme was developed based on the LDT framework for the analysis of LD artifacts and the interview transcripts. To refine the first version of the code book, a well-trained researcher, as well as one of the facilitators from the course was invited to perform inter-coding for one group's artifact. All three members of the course team met to examine and comment on the coding scheme and conduct several cycles of refinements. The intercoder rate is 0.982, which ensure the rigor of the study. The coding scheme is shown in Table 2.

Table 2. Coding scheme underpinned by the 7-step LDT framework (Law & Liang, 2020).

Dimensions	Items	Levels of attainments
Learning outcome specification	No info of Bloom taxonomy	0
	With multilevel learning outcomes defined in Bloom taxonomy (inCor)	1
	Only use Bloom taxonomy define the LOs of disciplinary knowledge and skills	1A
	Lack Bloom taxonomy to define sub-LOs	1B
	With multilevel learning outcomes defined in Bloom taxonomy (Cor)	2
Pedagogy	No info of pedagogy level	0
	With multilevel pedagogical framework based on the pedagogical approach (inCor)	1
	With multilevel pedagogical framework based on the pedagogical approach (Cor)	2
	Identify the key steps for pedagogical approach	2A
	Rearrange the key steps based on the authentic learning design needs	2B
Disciplinary practice	No info of DP	0
	DP does not provide steps to support learners' inquiry process	1
	DP provides steps to support learners' inquiry process	2
Curriculum component sequence	no info of mapping between LDT and CC sequence	0
	LDT generate CC sequence (inCor)	1
	Misunderstanding of CC	1A
	Only derived from DP or PA	1B
	Mapping between CC and LDT (Cor)	2
Task sequence	No info of mapping between CC and task sequence	0
	Mapping between CC and task sequence (inCor)	1
	Pedagogic strategy is not defined correctly or missing	1A
	Task sequence does not match CC	1B
	Mapping between CC and task sequence (Cor)	2

LO and tasks	No info of mapping between task or task assessment and LO	0
	With some alignment between LO, task, and assessment	1
	Only show the CC-based or session-based alignment between LOs, tasks and/or assessments	1A
	show consistency among specific LOs, tasks, and assessments	1B
	with strong constructive alignment between design of LO, task, and assessment	2
Task setting	No info of task settings	0
	with details of task settings dedicated for achievement of LOs (incomplete)	1
	with details of task settings dedicated for achievement of LOs (completed)	2
Learning analytics	No LA questions for LD	0
	With multilevel LA questions (inCor) for LD	1
	With multilevel LA questions (Cor) for LD	2

After the consolidation of coding scheme, multiple rounds of analyses were undertaken by the author in response to the research questions of the study. Throughout the whole data analysis process, the researcher adopted different principles to ensure the validity of the findings. Various data sources from different groups provides a relatively comprehensive triangulation and generate rich and thick description for the data (Creswell, 2007). Some participants were also invited to do the member checking for the accuracy of data interpretations for the interview transcripts.

Together with the encoding process with these aforementioned key concepts, a closer look at the interview transcripts and group design logs have elicited one key concept that was found to be the most difficult one for the research question 1. More details are presented in Chapter 5. Second, by checking the design trajectories of three groups against the course requirements in the 8 sessions, the findings in chapter 6 provided a more comprehensive view of learners' LD sequence and reasonings in related to the interventions in each session's requirements.

5. Results for RQ1: Challenges for Novice Learning Designers to Design the Learning Outcomes

RQ1 findings reveal design challenges encountered by the novice LDers. It is found that the design of Learning outcomes was a major focus and most difficult step in the design artefacts and interview conversations for all three groups. Several variations in relation to the conceptions of LOs emerged when the novice designers experienced different levels of design underpinned by the 7-step LDT framework. The findings have been structured according to three characteristics that emerged from novice LDers' LO design.

First, there is a tendency to focus on the content to be taught in different sessions of the course before the specification of LOs. Second, they were confused about whether

LOs should be general or specific. For example, they found that LOs were difficult to assess if they are too broad. Third, there was no explicit alignment among LOs, learning activities and assessments in the early versions of their LD artifacts. The direct quotes and design artifacts from participants are used to describe the characteristics.

5.1 Content and Activity-centered Approach

All three groups applied the content and activity-centered approach to their learning design when they developed the mini courses. Group A and B planned the learning activities, but they did not go into the detailed design like materials and resources in the early sessions. Group C reported they had spent much time in designing the activities before they planned the learning outcomes.

Group C-Y.L: We had a 6-hour group discussion about the learning activities after the first session. We were excited as we shared a lot of ideas for the learning activities. We believed all the learning activities were beneficial to our learners and we could not wait to designing the course slides for each session…We did not pay attention to LOs... but we needed to submit the presentation, so we tried to match them up in our way…

Except group B, the other two groups modified the design of LOs for several times during the 8-session of study. Group A were able to narrow down the topic which was familiar to them. Group C kept changing their topics every session.

Group A-J.W: Actually, at the beginning we listed several topics…We intended to engage students in the project of making a solar water heater. But most instructions are based on scientific experiment… We were more interested in scientific experiment. So, we search a lot of information about the primary science course topic and found that energy is one of the most important part for primary science topic, we were more familiar with this area. So, we finally choose this one and narrowed down the topic to a pure scientific experiment course.

Group C-Y.L: We always had new ideas at the session level and we tried to go back to modify the LOs at the top level… The reason why we changed the topic each week is that we were always going through the disagreement on the boundary of the course design, and each team member defines a version of learning outcomes from their understanding. Therefore, we finally decided to first set the learning activities and time allocation of each session, and then went back to define the learning outcomes.

5.2 Broad vs. Specific: The Specification of LO

In a similar way, course participants found that they were confused about whether LOs should be general or specific when they revised the LOs in the learning process.

Group C-Y.L: I was not sure what kind of words I could write in the learning outcomes. Are they supposed to be general or specific?

Group A-K.I: Should we directly put the specific LOs at first? or we can put the general one and then specify it later?

Group C-X.Y: For the first topic, We found that the design of LOs was not specific when we tried to connect the topic of each session to the learning outcomes. And we tried to narrow down a general set of LOs into each session. However, we could not do so.

5.3 Misalignment among LO, Content, and Assessment

All three groups ignored the alignment between LOs, learning activities, and assessments at the early stages of the design (see Figures 5, 6, and 7). The design of assessment was missing for Group A and B when novice designers presented their LDs in session 1. Group C kept changing their LD and they could only present the details of learning activities without LO and assessment in session 3.

Group C- X.Y: At the first session, we created a course outline (including assessments) to clarify our project at the first stage (I think things started to go wrong from that moment) because we thought if we could have created the outline surely we could show others how it would work. Now I realise it is counterproductive. We cannot explain well the LOs of our course from the very beginning, then the following weeks we again and again to revise the course learning outcomes and content which spent much time but few outcomes received.

Sessions	Session details	Related LOs
Session 1	Introduce basic concepts of thermal energy, insulation and energy transfer; Use the thermometer to measure temperature of materials; Discuss the daily life use of insulation	1,2,4
Session 2	Pre-class: video on solar energy; Online discussion about the benefits of getting warmth from solar energy. In-class: Introduce the solar water heater and project requirements; experiment to explore factors that influence the heating of the solar water heater	1,2,3,4
Session 3	Each group designs with their solar water heaters; compare the heating abilities of each group; group presentation, and grading; summary	1,2,3,4

Figure 5. Group A's LD on presentation document in session 1

Session #	Session Details	Related LOs
Session 1 (60 min)	**Understanding Urban Poverty** • Pre-class activities: Video + Reflection • Basic concepts of urban poverty, its causes and consequences globally and in HK • Introduction to Design Thinking • Post-class Group Task 1: Collect & share stories of people in poverty (Empathise, Define)	1, 2, 3
Session 2 (60 min)	**Multi-sector Supports & Young Change-makers** • Pre-class activities: Video + Reflection • How stakeholders from different sectors are contributing to solving urban poverty issues, in particular, the role young people can play • More cases and tools for Design Thinking • Post-class Group Task 2: Brainstorm & finalise proposed solutions for targeted issues (Ideate, Prototype)	1, 2, 3, 4
Session 3 (60 min)	**Youth Forum** • Keynote by guest speakers • Group presentations followed by feedback from guests and peers • Post-class Optional Group Task: Project implement (Test, Iterate)	1, 2, 3, 4

Figure 6. Group B's LD on presentation document in session 1

Session Date	Session details	Related LOs
Session 1	**Session theme: identifying reading competencies and difficulties in reading academic texts**	
	Learning activities: 1. Pre-course survey review (5 mins) 2. Discuss and identify the differences between undergraduate and postgraduate study (10 + 5 mins) 3. How to start your Master study: Let's start from reading (20mins) 4. Course Outline introduction (10 mins) 5. Preview of next session (5 mins) 6. Q&A (5 mins)	
Session 2	**Session theme: Being a Critical Reader**	
	Learning activities: 1. lecture: before you read, how to analyse the materials (10 min) 2. review the pre-course survey and group discussion the given answers in the survey (15 min) 3. lecture: the structure of the academic articles and deconstruct the providing academic text using the key reading skills (25 min) 4. lecture: introduce the main techniques of the note making (5 min) 5. Q & A	
Session 3	**Session theme: Close reading and annotation**	
	To be developed	
Session 4	**Session theme: presentation and reflection**	
	To be developed	

Figure 7. Group C's LD on presentation document in session 3

Group B and C explained that they focused on what they want students to do in each session so that they could achieve the learning outcomes without mentioning the assessment design.

Group B-O.W: I only thought of the activities like poverty museum (in session one), and poverty mind map (in session two) directly when we needed to support students to achieve the learning outcomes.

Group C-Y.L: We spent a lot of time to design the learning activities before we consolidated the learning outcomes because we believed this was the way we learnt. My group mate also shared with us how she learnt the academic reading skills by participating in the workshops and trainings. We were confident about the detailed design of learning activities, which would surely benefit our learners in some way.

Group C- X.Y: We summarized the tasks of each session from a session-level aspect to visualize what we do in the classrooms. Pre-class and post-class activities were also adapted to be aligned with the LOs.

In brief, although the specification of LOs is showed as the first step of the 7-step LDT framework, the novice LDers reviewed and revised the LOs at different stages of the LD and expressed their difficulties explicitly. *The design of LOs was admitted as the most iterative and challenging aspect of LD process.*

6. Results for RQ2: Learning Trajectories of Different Student Design Teams

By examining how three groups approached the LDs in the 8 sessions of learning, this chapter answered the second research questions: Whether and how the conceptions of LO changed during the course of study? What were the reasoning adopted by the students in their decision-making process?

The findings reveal diverse trajectories experienced by different design teams in their ability to specify LOs and the design alignment between LOs, learning activities and assessment of the minicourse.

6.1 Course Level Design

As the first step of the 7-step LDT framework, students from different groups are required to define the learning outcomes. As discussed in chapter 5, all three groups defined the LOs from the learning topics and content that would be covered in the lectures. They did not consider the constructive alignment in their first LD.

The course facilitators introduced the outcome-based design principle and constructive alignment and invited students to review the design of LOs. The data suggested that students acknowledged the advantages of the outcome-based approach.

Group A-J.W: the course facilitator makes me more clear about when you are designing a learning outcome, it should be measurable. So, we can measure the students. If I'm not mistaken, it is mentioned in our session one. The outcome-based approach.

In addition, three constructs including learning outcomes, disciplinary practice, and pedagogical approach from the LDT framework, were used to scaffold the course-level design. The curriculum component (CC) is the key building block derived from the three constructs to help learners specify the learning outcomes for each block. Students could further specify the learning outcomes for different CCs. Group B used the LDT to construct the CCs and further develop the learning activities under each CC (see Figure 8 & 9). However, the assessment design was not mentioned explicitly in their session 2's LD.

Group B-O.W: We designed a general version of LOs in our first LD artifact, based on what we would teach in each session in the course. However, our later version of LOs is different. We learnt the way to design LOs in session 2 and we specified four types of learning outcomes. We also became aware that we need to further specify LOs when we planed the curriculum components (CC) (see Figure 8 & 9).

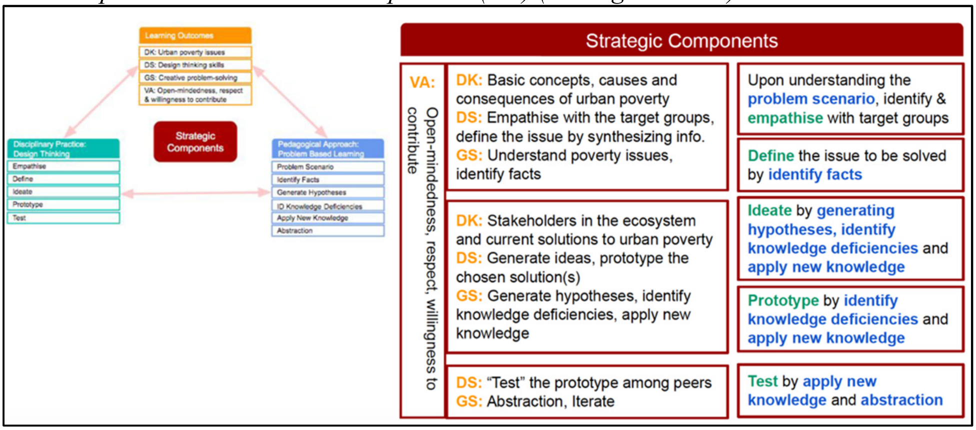

Figure 8. Group B's CC design on ppt presentation slides in session 2

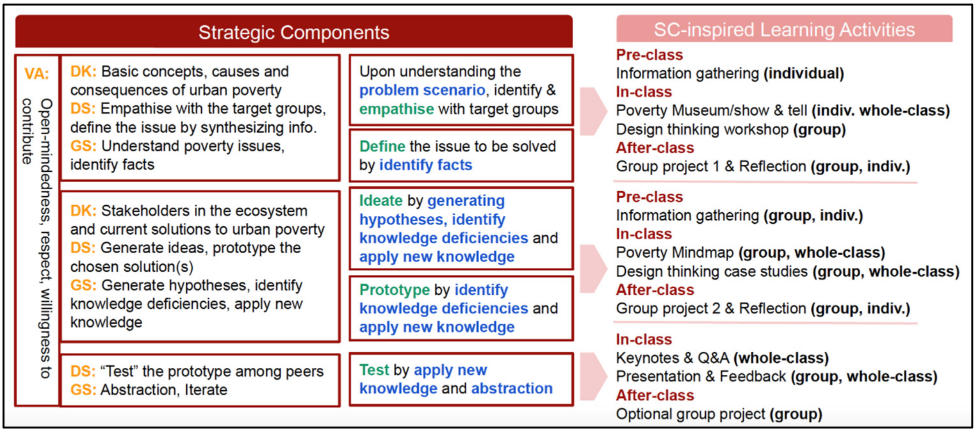

Figure 9. Group B's CC design on ppt presentation slides in session 2

On the other hand, group C stated that the unfamiliarity for the course topic would probably be responsible for the failure of consolidation of LOs. They decided to change their topic at the midway through the course. They restarted their design work from step one in the LDT.

6.2 CC and Task Level Design

The next step is to design the task sequences of the CCs in session 3-5. Learners were required to refine their design of previous sessions and to conduct the task design for CCs. They started to use LDS to visualize the design of tasks including the length, social organization, and venue. By reflecting on the dashboard visualization on LDS, learners were expected to check whether the CC design aligned with the course level.

Group A shared their conception of CC in session 2's design log. They continued to revise their LO design. This resulted in their understanding of the importance of alignment among the learning outcomes, tasks, and assessment design (see Figure 10, 11 & 12).

Group A-B.Y: When it turned to the CC level, we looked back to the learning outcomes. We think that it's not specific enough and we don't know what student actually need to accomplish. So, we just made them more detailed. They can also be a guidance for our task design in each CC.

Group A-K.I: We think that CC is a sequence of activities that the students will have in the course. The CC must relate to the disciplinary practices (DP) and pedagogical approach (PA) used in the mini course to achieve the LO, so each CC must have outcomes. CC will guide the process of learning design because it is the bridge between DP, PA, and LO. Defining CC helps us in creating task setting and assessment for the students.

Group A-B.Y: Once we decided on the pedagogical approach and disciplinary practice. We can just follow the framework and proceed to task design. For example, the first CC is orientation. Then we do some knowledge introduction, and some appropriate task activity for primary school students to complete.

Second, they also indicated the role of social interactions in the course such as peer evaluation for the session work and discussion at the beginning of each session, whereby they managed to refine CCs through observation and reflection.

Interviewer: What makes you understand the CC and use it in your group design?

Group A-J.W: We learnt from the teacher feedback for our group presentation and by watching others' presentation.

Group A-K.I: The facilitator gave us an example in the lecture that also helps me to learn about the CC.

Group A-B.Y: Yes. And also, the continuous discussion in our group.

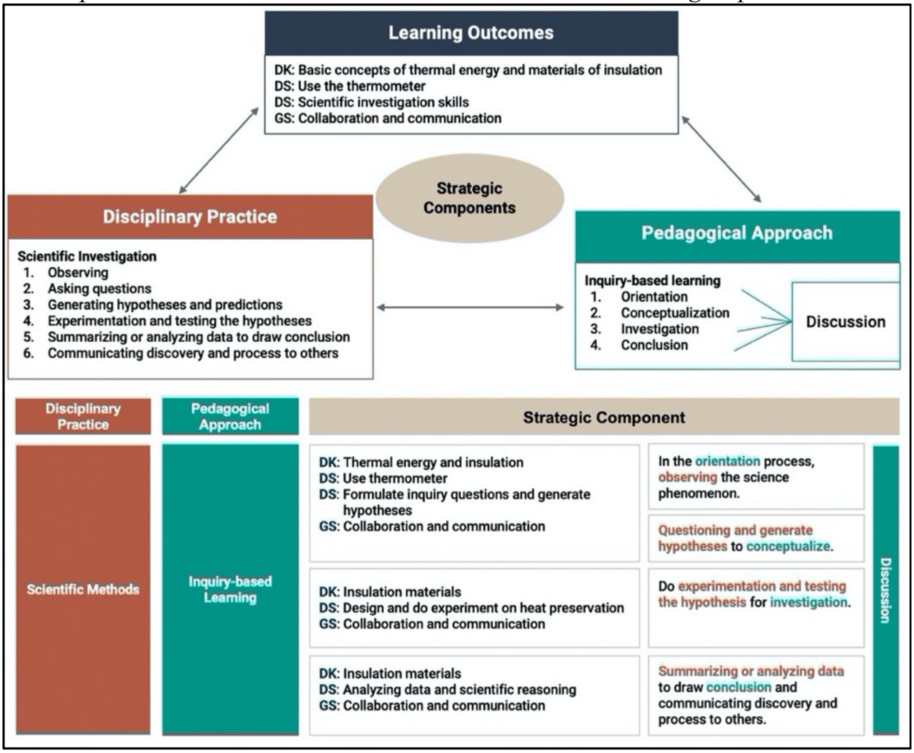

Figure 10. Group A's CC design on ppt presentation slides in session 3

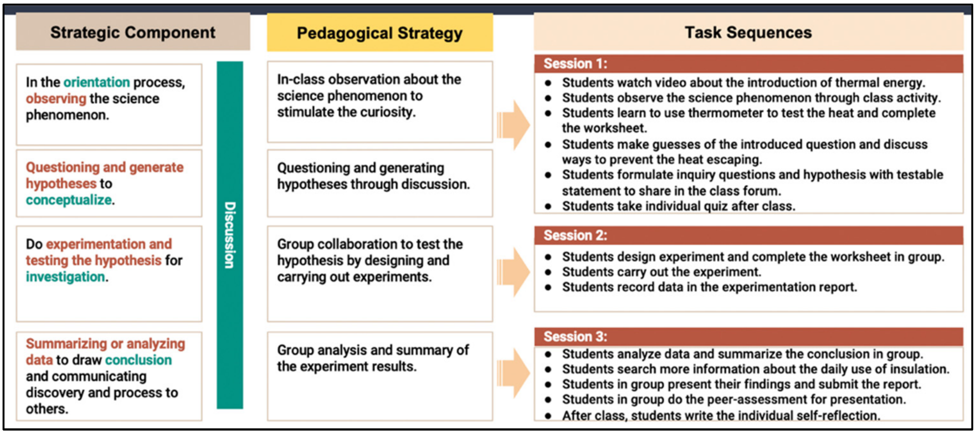

Figure 11. Group A's CC design on ppt presentation slides in session 3

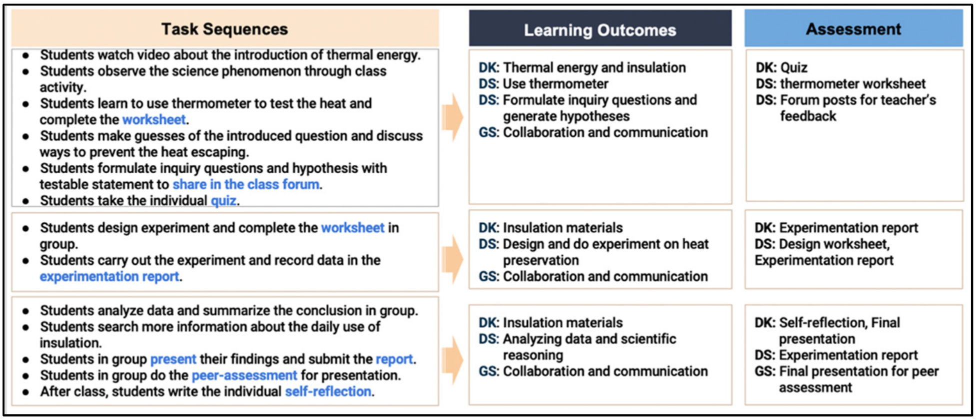

Figure 12. Group A's LO design on ppt presentation slides in session 3

On the other hand, although group B and C proceeded to task sequence design, a recurring theme is their LD is their difficulties in aligning the learning activities, assessment and the learning outcomes. They thought of the learning activities in each session and hardly revised the design when changes happened to the course level in terms of LO, DP, and PA.

Group C-O.W: The design of pedagogical strategies (for each CC) is very challenging to me. There are no suggested options for pedagogical strategies on LDS and we could not figure out by ourselves…The task sequences were designed based on our assumption of which activities would be more appropriate to support our learners. We discussed a lot and exchanged our own experience with group mates.

The expressions from group B and C indicated the confusion in the multilevel design and its alignment. Group B seldom revised their LD while Group C was struggled with the course topics during session 3 to 5.

6.3 Alignment Check

Group A are more likely to demonstrate a productive progress in constructing a constructive alignment across different levels over time. By referring to the LO, DP and PA defined at the course level, Group A could operationalize ideas gleaned from the literature to design a coherent set of learning experiences and assessment design to achieve the intended LOs. By referring to CCs derived from the well-structured steps of DP and PA, Group A tended to be easier to figure out the operationalized suggestions from the literature and draw a coherent learning experience for the intended LOs strategically. For example, group A was able to identify and address the key LD issues explicitly by the specification of LOs, whereby the design of the corresponding CCs and their task sequences and tactics updated correspondingly.

Group A-B.Y: In our initial design, there are only three sessions in the entire course, including theoretical knowledge, experimental practice and summary. However, after study and discussion, we believe that three sessions are not enough for students to master sufficient knowledge to carry out exploratory practice with certain difficulty. So, we've expanded the entire course into four sessions. In the revised learning design, session 2 & 3 are the most important, in which we set a set of corresponding practical activities and demonstration tasks…In session 3, students will take a leading position, with gained knowledge from the previous session, take part in experiments and tests, inquire about their hypotheses, and generate results. This process is the formation and practice of students' scientific thinking and inquiry skills.

In contrast, teams that lack a comprehensive understanding of LDT tended to map out the LDs in a mechanical and linear way without revisiting the design of LOs. Group B did not have a full understanding of LDT tended to map out the LDs in a more linear way. It is found that group B could hardly evolve the design of LOs and CCs in such a way. Group B structured the LD with LDT and CCs at the early stage but turned their attention to activity blocks called “CC-inspired activities” after they got stuck by the multilevel structures on LDS.

Group B- O.W: We had a broad concept of learning activities for each session in our mind at the very beginning, which might probably lead to the confusion between the learning activity level and curriculum component level on the LDS...

We know that the poverty museum is corresponding to the (CC of) identify and emphasize with target groups. However, I was not familiar with the terms at that time when we used the LDS. It turned out that I thought of the activities like poverty museum (in session one), and poverty mind map in session two intuitively when we needed to help students achieve the learning outcomes… As a result, we designed 11 CCs. We received the feedback that they were too many. I did not realize that one CC can be arranged into both the pre-class and in-class sections until I suddenly noticed this function when I used the LDS after class one day.

Now I have a clear understanding of CC, which plays a role to integrate pedagogical approach into the discipline that I am going to teach, and the related disciplinary practices for course design. It would be better if we could avoid the technical pitfall and misconceptions by participating into the training for LDS before we use it for design.

Group B probably had a vague alignment when they first constructed the CCs. However, they lost sight of the overall course coherence easily by turning the CCs into activities, which literally could not visualize an explicit sequential relationship for learning to proceed. The previous literature also suggested that the biggest challenge lies in the adoption of a coherent pedagogical approach and the pedagogical strategy to further facilitate the development of learning tasks and resources without losing the coherence (Law & Liang, 2020; Warr, Mishra, & Scragg, 2020).

On the other hand, participants who are less experienced in the topics chosen are not capable to specify the LOs. Group C attempted two subject matter topics in two distinct ways during the course of their study. Referring to their first topic, the group members indicated that their unfamiliarity with the subject was probably responsible for their failure in specifying appropriate LOs, resulting in their "jumpstarting" to designing course material design problematic, and their subsequent inability to proceed to the design of assessment tasks to match with the intended learning outcomes at the course level.

In their second attempt, group C switched their topic to build job-seeking skills. They started by specifying the elements of the LDT, followed by identifying a sequence of steps that job seekers would normally go through. They also worked back and forth to revise both the LOs and tasks whenever they found the task sequence could not be designed to achieve the LOs.

Group C-L.K: For the new topic, we adopted project based learning as the PA. We supposed that learners would need different artifacts for preparing their job interview. Then each artifact could be regarded as a small project which contributes to the overall project. For example, we designed CV as one of the projects during the learning process. We will evaluate and assess students based on their conceptual artifacts or tangible artifacts, and design comments, peer feedback, and teacher feedback to support learners. And this is how we aligned the CC and session levels.

7. Discussion and Conclusion

The overarching objective of this study is to figure out what design challenges the course participants encountered while they approached the LD professional practice and expertise, how they interpret, whether and how they changed the conceptions during the course of study, and what factors influenced learners' decision-making process.

This preliminary research firstly provides empirical experience of how the 7-step LDT framework could scaffold the conceptualization and development of a LD coding scheme. The feature of "LD analysis" is mentioned in the study of the LDT framework (Law & Liang, 2020), but there is no detailed description about what levels of attainments are associated with the key indicators of the framework. The coding scheme could be adopted by researchers in their analysis and evaluation of individual LD artefacts, as well as the design trajectories of approaching LD practice.

Second, this study contributes more insight for the challenges and research gaps about the pedagogical integrity between the intended theoretical concerns and the development of specific learning tasks for implementation (Conole et al., 2004; Persico & Pozzi, 2015; Warr et al., 2020) by unpacking how participants' decision-making process in developing their LD expertise in the 8-session course of study and eliciting the enablers and barriers for them to cope with the LD issues emerged from different levels. While the previous literature of LD to evaluate the effectiveness of the PD programs underpinned by the LD frameworks that varied in terms of the targeted levels of granularities or design practices, The implication is the empirical evidence for evaluating a full LD cycle underpinned by the multilayer representation that encompasses the four-layer pedagogical considerations (Goodyear, 2005).

Regarding the implications to design practices, first, findings may offer some guidance and recommendations for educators and teacher trainers who may wish to develop an LD related PD program or an inquiry-oriented course design, with a backward design to align the task and assessment to the disciplinary and 21st century outcomes. While Mor and Abdu (2018) defined LD as a form of practice represents the pattern of activities that lead to the achievement of specific goals, they stated the importance of (Law et al., 2017) As such, the design studio approach and environment design consisting of peer review, formative feedback, group collaboration, and presentations could be further adopted into educational or other design-related disciplines to facilitate learners to engage and perform in cycles of inquiry about the new concepts which are assigned strategically in different stages of learning while synergizing the final design artefacts.

Findings from this study also revealed that the LDT framework is relatively complex with key LD concepts that are interrelated in nature. While the previous conceptual and design tools mentioned in the LD literature attempted to scaffold the design for the specific levels (Boloudakis, Retalis, & Psaromiligkos, 2018; Conole et al., 2004; Laurillard, 2012; Toetenel & Rienties, 2016), the digital platform Learning design studio (LDS) is crucial in learners' cognitive development of conceptions across multiple levels of LD. This study may provide references for the research and design team of LDS by offering a systematic and explicit documentation of user experience and possible design and technical issues that LDers would encounter when they followed the instructions at different stages of learning. The research and design team of LDS might need to pay attention to the clarification and scaffoldings of LD constructs at the specific design level as well as to visualize the pedagogical considerations across levels for the future development.

Finally, the curation of different LD artefacts in this study, which is diverse in different education level (primary, secondary and adult education) and disciplinary focus (STEM and humanities) may also help broaden LD practitioners' ideas on how to navigate different resources and tools and work collaboratively in the real work situation. The important implication would be the contribution to practical advocacy from LD literature of sharing pedagogical practices and building participatory culture among LD researchers and practitioners (Conole, 2013; Persico & Pozzi, 2015; Ronen-Fuhrmann & Kali, 2015), including not only teachers, but also to a larger group and community in the educational professions (Law et al., 2017). While there are several tools, taxonomies, and constructs for practitioners to document their design thinking in different representations and levels, findings reveal that it would probably be easy to lose the focus of coherence in the overall design if LDers only focused on specific learning activities and course materials. As such, researchers and designers involved in the LDS development could consider making it as a multilevel repository and communication channel to capture and organize various resources and case examples for public access by the educational practitioners of different roles and expertise across different educational settings and contexts.

This paper presented an in-depth case study for illustrating the progression and development of course participants' LD understanding and artefacts. However, the findings cannot be generalized directly across different LD training settings and contexts elsewhere. Potential studies could be carried out to the professional development courses for in-service educators to explore whether experienced designers encounter similar challenges when designing with the LD terminologies. Educational practitioners may have relatively rich educational experience and understanding of student learning while their priorities and demands are often influenced by institutional and disciplinary factors.

A further limitation of this study is the lack of insights into intra-team interactions. First, because of the outbreak of COVID-19, the class changed to full online mode after the first session. It is impossible to observe how students interact with each other in the follow-up discussion after the lecture, which was originally planned in the course schedule. Second, in this study, groups were treated as a unique case for data collection and analysis. The evidence for group rapport and consensus development are based on participants' self-reported data. Further study could attempt to provide a full perspective of LD training by collecting data from observation regarding the dynamics of the team design.

Finally, this study is the first preliminary case study to test the 7-step LDT and LDS framework in the context of a master-level PD program. The whole learning design of the program took eight sessions to proceed with enduring support and interaction among course facilitators and students, students and students. In the future study, different educational settings, user groups and durations could be adopted to examine the effectiveness of the framework and tool.

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A Blended Physics Experiment Teaching Environment: What Do We Expect？

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Abstract
Purpose – During the time of the COVID-19 epidemic, the College Physics Experiment course with its practical curriculum accepted the challenges and reflected on them. Compared with the traditional teaching method of demonstration, learning with online resources has many advantages, such as the ease of updating content and providing more time to experiment and explore. The direction of reform in the Physics Experiment course after the epidemic was under control involved an increase in the proportion of online resources and the enhancement of the integration of online and offline teaching. This paper aims to introduce our approach and share our experience with other researchers for reference.
Design /methodology/ approach – Based on Bandura's Reciprocal Determinism, we developed a platform for the teaching of physics experiments which could be used on a mobile phone. With guidance from an experiment shown on the project module, students did an experiment on 'measuring a signal with an ST16A oscilloscope' and accomplished it by themselves. To evaluate the effects on students, we adapted the URSSA scale (Undergraduate Research Student Self-Assessment) and investigated four aspects — their satisfaction with teaching support, knowledge acquisition, personal income and the experimental attitude and behaviour.
Findings – The results showed that online resources can achieve the basic knowledge acquisition; and there was no significant difference in the satisfaction with teaching support between the experimental and control groups. However, it was also found that the students in the experimental group were not as good as those in the control group in their experimental literacy, motivation for learning and the desire to explore. This may have been due to insufficient interaction in the design of the online resources. The lack of contact with offline activities leads to the lack of teachers' influence and a learning atmosphere.
Originality/value/implications – This paper analyses students' learning capacity in the application of practical teaching. We know that in the development of online resources, we should pay more attention to the connection with offline teaching activities, rather than focusing on the content construction alone.

Keywords: Blended Learning, Mobile Learning, Physics Experiment Teaching, URSSA Scale

1 Introduction

During the COVID-19 epidemic era, all schools have adopted online teaching. Teachers changed their teaching mode passively and tried to explored advantages of online teaching constantly and applied them to practice. With the strong support of Rain Classroom teaching platform, Zheng and Zhang (2020) designed the task-based instruction which improved students' interest in class and assisted their self-learning after class. Li et al. (2021) assigned the search task of physical information to students, which not only enriched students' understanding of physics but also exercised their ability of analysis and identification. Zhang et al. (2021) based on the accuracy statistics of students' online choice questions to adjusted their teaching rhythm in real time. Sum up these practice and reflection in college, we can find many advantages of online teaching. Firstly, both the breadth and depth of online learning resources are far beyond what teachers teach in the classroom. Secondly, all students' learning tracks on the Internet are recorded, which can be used for accurate decision-making to improve the quality and effectiveness of teaching evaluation. Finally, it is an available chance to exercise students' self-control ability and train their self-learning consciousness and inquiry ability without teachers' supervision and guidance (Liu, 2019). After all, the knowledge is easy to forget and the learning ability is always with you.

In the long run, the blended learning will be the most popular teaching mode and online teaching will be as common as the classroom teaching. In the Post-epidemic Era, the physics experiment course characterized by hands-on practice should also actively think about the reform to increase the proportion of network resources and strengthen the integration of online and offline teaching activities.

Based on the Bandura's Reciprocal Determinism and focusing on the teaching characteristics of physics experiment, Tongji University has developed a physics experiment teaching platform to assist the implementation of offline teaching activities, which includes the functions of equipment introduction, project writing, competition participation and course learning. This research is based on the most basic module part to test the using effects, and it is also expected to give suggestions on how to promote the integration of online resources and offline experimental courses from the feedback of students.

2 Platform Design

2.1 Design Points

In the 1960s, based on the research of Lewin model, psychologist Bandura proposed that human behavior was formed by the interaction of three elements, namely, behavior, human internal factors and environmental influence. They were connected and determined by each other (Bandura, 1989). According to this theory, we summarize three design points of online teaching platform in Figure 1.

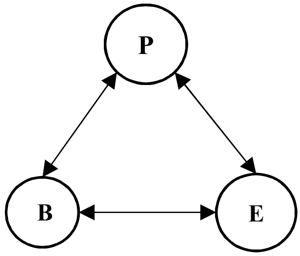

Figure. 1 three-dimensional interactive model

1) Create a Personalized Environment

Different environment will affect person's self-evaluation and change their personality. In the hearts of students, campus has always been the learning place. As soon as they enter, they realize that "it's time to study". But virtual Internet environment lacks learning signals. Therefore, the first step is to create a pure learning atmosphere where there are students, teachers, learning space and learning support. In addition, taking the special teaching mode into consideration, the platform should be allowed to add personalized teaching activities, such as scientific research activities, collaborative activities, innovation activities and so on. In a word, environment is the guarantee of behavior. Different activities need different functional support.

2) Stimulate Students' Subjective Initiative

Person is the subject in the environment. His cognition can control his behavior and his personality can activate different environment reactions (Lopatto,2004; Wang,2011). In the online environment, due to the increase of students' conduct freedom and the decrease of teachers' real-time supervision and intervention, students' learning autonomy and their own learning ability become the key to the teaching effect. Therefore, different from the demonstration teaching mode in the offline classroom of physics experiment course, we should encourage students to design experiments and verify research hypotheses independently in the network learning environment. Only by cultivating students' subjective initiative and training their autonomous learning ability, can online teaching maximize its benefits and promote sustainably.

3) Strengthen the Guidance of Behavior Activities

The knowledge, experience and reflection learned in the whole practice will change person's thinking, will and motivation subtly (Hunter et al.,2007). In the classroom, teachers spend most of their time on content delivery. But when online teaching is integrated, they should pay more attention to the learning methods and attitudes. Compared with teaching students "what is this", it is more important to tell them "how to learn". Therefore, it is necessary to design appropriate scaffolding in teaching resources to guide students' autonomous learning. Besides, teachers also should spend more time on the supervision of learning to provide timely help.

2.2 Functional Modules

We have designed a physics experiment learning platform based on the three principles, which students can use on mobile phone or computer. As shown in Figure 2, the system is based on B/S architecture and supports students from all over the country to use it at the same time. Besides, adopting Model View Controller design pattern, the system is easy to maintain and has good expansibility. Spring Boot and Vue framework make the system easy to deploy, low cost, data security and real-time synchronization.

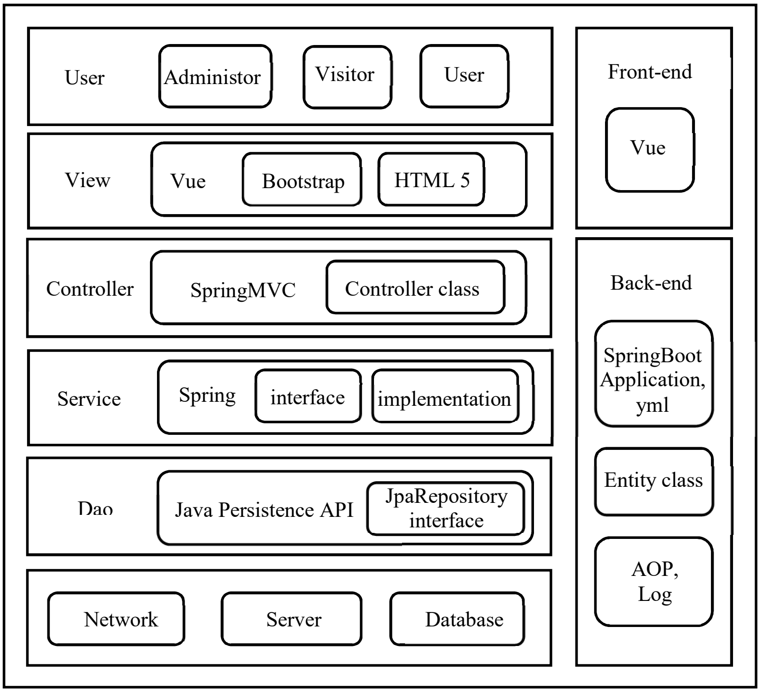

Fig. 2 System architecture of teaching platform

The system includes four modules: equipment, project, course and competition, which can meet the general needs of physics experiment teaching.

Teachers can publish e-books here and students can share their daily creation. All users can build resources. Then, we introduce the function of each module in detail.

1) Equipment Module

Equipment is a measurement tool in physics experiment, which determines the experimental error and affects the experimental results. Recording the model type in time can help others to better repeat and verify your experiments, or carry out further exploration on the basis of your experiments. Therefore, taking the foundation and necessity into consideration, equipment module is designed. All of the users can add and edit equipment information in the equipment database. And all of the equipment records stored in the equipment library can be quoted directly when users write experiment reports.

2) Project Module

Experiment report is one of the main communication means of physics experimental course. The publisher writes his own project background, equipment, process and results in the report and other users read, praise and comment when it is released. Based on this function, teachers can update and present the experimental content timely in the form of e-books and students with strong learning ability or curiosity can show their achievements. All of the rich resources will also be public to the students with poor learning ability and help them to make up for their vacancy. It is believed that if teachers can consciously manage the project communication forum and maintain the connection between learners and promoters, it is likely to be a thriving learning environment. In addition, based on this module, teachers can carry out the research-based teaching mode to exercise students' research ability and let them fully realize the value of the research (Ciarocco et al., 2013).

3) Course Module

The course module takes courses as units. Teachers form a new course by organizing multiple related projects from the project database or writing by themselves. Therefore, the course module is the summary of the project library, which is convenient for students to systematically study by themselves.

4) Competition Module

Participating in physics experiment competition can stimulate students' active learning and strengthen their theoretical understanding by applying it to practice. During the competition, students' learning ability, practical ability, problem solving ability and innovative spirit will all be improved comprehensively. Therefore, the combination of competition and teaching is a popular teaching mode in physics experiment course(Zhou,2020). The competition module is completely managed by teachers and includes the whole preparation tasks of organizing a competition, including the functions of creating, editing, publishing and deleting. Editing events specifically includes editing the competition information, publishing the competition notice, designing the scoring scheme, adding judges, reviewing the qualifications, showing the entries, publicizing the results and other basic competition planning work. In conclusion, the competition module has clear guidance and complete functions. Based on this module, the third national university physics experiment competition has been successfully held.

3 Research methodology

This research uses the basic function in project module to investigate the platform using effects, including students' satisfaction with teaching support, knowledge acquisition, personal income and the experimental attitude and behavior.

3.1 Research Context and Participants

The experiment of "measuring signal with ST16A oscilloscope" is taken as the content, which requires students to be able to measure the amplitude and period of the specified signal by using the oscilloscope, and display the corresponding Lissajous figure by adjusting the function signal generator. This experiment is so representative that it is one of the six basic physics experiments in the first semester for undergraduates. In the survey, 243 freshmen from Tongji University participated and were divided into the experimental group and the control group. They are mainly engineering students, distributed in five schools, and the proportion of male and female students is close to 5:1.

3.2 Research Design and Data Collection

The study evaluates students' learning results by the score of experimental operation and classroom quiz, investigates the differences of classroom satisfaction, experimental attitude and behavior, and personal income by URSSA scale.

In the experimental operation, the requirements for two groups are same, and they all evaluated by the teacher in class. In the control group, the teacher demonstrates and explains the detail and process of the experiment with the projector in the first 30 minutes. Students do the experiment by themselves and fill in the experiment report in the next 60 minutes. In the experimental group, students are required to learn by using the experimental operation manual in the platform as the Figure.3 shown. The content of the manual is intuitive and comprehensive, which is almost the same as the teacher's explanation in class. In the 90 minute course time, except for the task assignment in the first few minutes, the rest of the time is all for students. In addition, it is worth noting that teachers won't offer any help in the whole experiment. And considering the existence of answer plagiarism online, two groups of students are forced to raise hands immediately after realizing the required Lissajous image and be examined. In the classroom quiz, we design four multiple-choice questions with similar difficulty and publish at the beginning of the class. After class, we compare the accuracy of their answers.

Fig. 3 The learning scene of the experimental group

Referring to The Undergraduate Research Student Self-Assessment (URSSA) scale, this study investigates students' classroom evaluation, experimental attitude and behavior, and personal income (Weston,2015). Among them, the dimension of classroom evaluation is students' satisfaction with the support provided by the course. The dimension of experimental attitude and behavior is to investigate students' attitude and understanding of physics experiment course. The dimension of personal income mainly investigates the change of students' learning motivation and the mastery of knowledge during the experiment. Finally, 243 questionnaires were collected, including 195 in the experimental group and 48 in the control group. The Cronbach'α of the scale is 0.941 and construct validity is 0.931. Therefore, the scale has good reliability and validity, which can truly reflect the feedback of students.

4 Result

4.1 Knowledge acquisition

Students' learning effect was investigated from two aspects, the results of classroom quiz and operation score. For the classroom quiz, we counted and compared the accuracy of the two groups by independent t-test. Table 1 shows that the average score of the experimental group is significantly higher than that of the control group, especially in the operational questions. It can be seen that the students can complete the teaching objectives by self-study, and it is possible that the experimental group students solve the problem more consciously with the help of equipment. Comparing the experimental scores of the two groups, we find that the average score of the experimental group is significantly lower than that of the control group. Interestingly, the discrimination of the experimental group is 11% higher than the other. This shows that students' differences are magnified in the process of autonomous learning, which is more conducive for teachers to find students who are poor learning and provide guidance timely.

Table 1 The result of independent t-test about knowledge acquisition

content	Group	Average	Sig.
score of classroom quiz	the control group	2.94	0.000*
	the experimental group	3.36	
score of experiment operation	the control group	85.53	0.009*
	the experimental group	83.44	

4.2 Satisfaction with teaching support

Table 2 indicates that there are significant differences in problem solving between the two groups. The experimental group is harder to solve problems and less satisfied with the teacher support provided by the platform. A complication in interpreting these results is that the background of our investigation is examination, so teachers and peers are forbidden to offer help. But these results also reflect that teachers' targeted guidance is still what students need, and in contrast, the awareness of cooperation and communication between students is weak. Interestingly, we can see from the result of "I like this experiment class" that although it's harder to achieve learning goals, students prefer the form of autonomous learning. A possibility is that this experiment is less difficult and students are proud to complete the experiment by themselves and their learning enthusiasm is improved.

Table 2 The result of independent t-test about classroom evaluation

Item	Group	Average	Sig.
The difficulties encountered in the experiment can be quickly solved.	the control group	4.2292	0.026 *
	the experimental group	3.9231	
I am very satisfied with the experimental equipment.	the control group	4.3542	0.124
	the experimental group	4.1128	
I am very satisfied with the exchange and help between students.	the control group	4.2917	0.156
	the experimental group	4.0564	
I am very satisfied with the teacher's explanation and guidance	the control group	4.4792	0.029 *
	the experimental group	4.1692	
I'm very satisfied with the chance that if I have any questions, I can communicate with the teachers at any time	the control group	4.3125	0.025 *
	the experimental group	4.0308	
I like the teaching method of this experiment class.	the control group	1.0208	0.000 *
	the experimental group	1.2872	

4.3 Experimental attitude and behavior

There are significant differences in the statement "I want to improve this experiment". It shows that in the process of self-study, the students in the experimental group think more about the details of the experiment and find some shortcomings of the experiment. While the control group students may pay more attention to copying the teacher's operation rather than understanding it before doing. In the another item "if I can't come up with an answer quickly, I tend to ask other people", there are also significant differences. When encountering problems, the students in the experimental group are more inclined to solve by themselves. This may be due to the support of experimental guide which is taken as a learning resource. The results of the above two statements reflect the advantages of online teaching in physics experiment teaching. Giving students more personal time and appropriate self-learning resources is more likely to help stimulate their in-depth thinking.

Table 3 The result of independent t-test about experimental attitude

Item	Group	Average	Sig.
I want to improve this experiment.	the control group	1.8333	0.024*
	the experimental group	2.0769	
If I can't come up with an answer quickly, I tend to ask other people.	the control group	1.5208	0.042*
	the experimental group	1.3538	

4.4 Personal income

College students have formed personalized knowledge learning methods, so their learning difficulties are also different even in the face of the same knowledge points. In the item "the problems encountered in the preview will be solved in the experimental practice", there is a significant difference between the two groups. The students in the experimental group have better solved problems met in the preview. Therefore, in the fundamental experiments, if teachers give students more time and freedom to carry out with their own idea, the knowledge they gain will be more effective and high-quality to themselves.

Table 4 The result of independent t-test about personal income

Item	Group	Average	Sig.
The problems encountered in the preview will be solved in the experimental practice.	the control group	1.2500	0.001*
	the experimental group	1.4923	

5 Discussion

According to the above experimental results, we can find that students in Tongji University can learn confirmatory experiments independently, and master the relevant knowledge. However, we also find some weakness that need to take seriously. The results are shown in the figure 3. The average value of each dimension in the scale was calculated after standardization. Seen from the radar chart, the experimental group is not as good as the experimental group in terms of self-confidence, desire to explore, learning motivation and the experimental knowledge, except for the acquisition of knowledge.

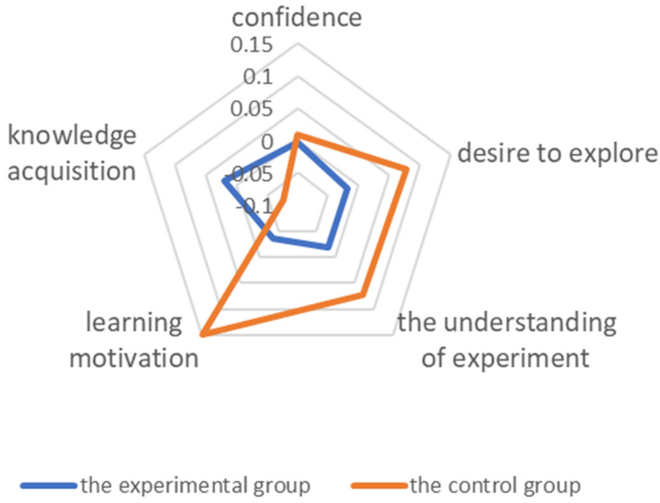

Fig. 4 Comparison of using effects of two groups students

We reflect on the causes of these results and draw the following suggestions for online resource.

1) No matter under the guidance of teachers or study by themselves, students' self-confidence is insufficient. The most likely reason is that the autonomous learning is challenging and the learning resources don't provide enough support. So we can set incentive factors to protect and improve students' self-confidence at first and then present scaffolding and respond promptly.

2) Desire to explore, learning motivation and the experimental knowledge are interrelated. We try to analyze the reasons why these three dimensions of the experimental group are not as good as the traditional group. One possibility is that students lost the details observation about the teacher's experimental operation, especially the experimental specification. Online teaching is hard to convey the abstract content. But the virtual simulation experiment system can make up for this deficiency. Of course, we should also add the laboratory specification content in the e-books and examinations.

3) The other possibility is that the form of multimedia is not rich enough and students do not find the meaning of experimental research. Therefore, we can try to expand the depth and breadth of learning materials and arrange more content about the practical applications of this knowledge point in life. It helps students eliminate the strangeness of abstract knowledge, so as to stimulate their interest in explore.

To summarize, we should pay more attention to the integration with classroom teaching and create an emotional learning environment when designing resources. Focusing on the organization of content alone is not enough. The function of this platform needs to be combined with offline teaching activities to maximize its effectiveness. The physics experiment teaching center of Tongji University plans to develop more teaching cases based on this platform and promote the reform of physics experiments.

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Should I Complete My Degree Online? Perspectives of International Students During the COVID-19 Pandemic

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Abstract

Purpose – Due to the COVID-19 pandemic, many international students have difficulty in returning to the host country and university. As a result, university administrators established technologically-assisted teaching and learning platforms for students who cannot come to the campus for their courses. However, most of the British taught Master's degrees only require students to complete their programme in one full-time year. The current study aims to understand the motivation and reason why these students decide to study completely online instead? For this purpose, two research questions were established:

(1) Why did these postgraduate students decide to complete their Master's degrees completely online during the COVID-19 pandemic?

(2) How would these students describe their experience of, and decision-making process for, pursuing a Master's degree online?

Design/methodology/approach – This study employed the Social Cognitive Career Theory as the framework for understanding the motivation and reasoning of these groups of Master's degree students who chose to complete their degree completely online during the COVID-19 pandemic. The general inductive approach was employed. The 156 participants were invited to complete an online-based inductive survey about their motivation and reasons based on the theoretical framework. The survey questions involved both open-ended and semi-structured questions. The grounded theory approach to data analysis was employed. Based on the open-coding and axial-coding techniques, the researchers merged two themes and three subthemes.

Findings – Based on the participants' sharing, the researchers captured the understanding and description of how the current social situation, financial considerations, and the limitations on international travel could have a strong impact on the decision-making process. Potential themes were outlined, including the same valued between on-campus and off-campus courses, and financial considerations.

Originality/value/implications – The results may contribute to the current knowledge and practice about how postgraduate students select their learning method, the decision-making process for programme selection, and future programme development. University leaders, department heads, programme developers, university students and researchers may use the findings of this study to reform their online-learning platform and programme design in order to meet the needs of future postgraduate degrees and online-based programmes.

Keywords: decision-making process; motivation; postgraduate education; online learning; social cognitive career theory

1 Introduction

Distance-learning degrees and courses are a recent educational trend. Unlike traditional-age students who can study their degrees as full-time learners, most non-traditional, returning, evening, and adult students (NTREAs) have family and financial responsibilities which do not allow full-time engagement (Dos Santos, 2020b). As a result, many universities have decided to establish distance-learning programmes at the undergraduate and postgraduate level to meet the learning needs of these students (Brown et al., 2015; Mozelius & Hettiarachchi, 2017; Simonson et al., 2008). Although distance-learning programmes do not require face-to-face instruction on-campus, students are still required to submit assignments, complete exams, attend seminars, and finish readings for each module and stage. A previous study (Lim, 2016) indicated that distance-learning programmes require self-discipline and self-motivation, as peers and instructors are not physically present to guide and enhance the learning experience. Students who cannot balance the schedules and assignments are more likely to drop out of their programmes (Gregori et al., 2018; Heidrich et al., 2018). One of the problems facing enrolment management is the dropout rate from both on-campus and distance-learning-programs. To solve this problem, it is important to understand why students decide to start and enrol in learning programmes, particularly distance-learning programmes. A recent study (Gregori et al., 2018) outlined the dropout rate of a European, distance-learning-based university. The study indicated that students in science-oriented programmes were more likely to drop out of their programmes, whilst social science and humanities students were more likely to complete their courses. For example, whilst only 30% of art history, psychology, English, social education, and geography students left their programmes, more than 50% of physics, industrial, mathematics, and electronic and automation engineering students dropped out, as did over 60% of those in chemistry, mechanical engineering, and electrical engineering programmes. (Gregori et al., 2018)

Although these students left their programmes for a variety of reasons, some researchers (Heidrich et al., 2018) have argued that learning styles and previous learning trends are a major influence on how students describe their experience and motivation to continue. However, other researchers (Yukselturk et al., 2014) have argued that these students decided to drop out of the distance-learning programmes because of the virtual learning experience. Some students expected to have an on-campus experience (e.g. the social activities and interactions between peers and instructors), which distance-learning programmes could not offer (Lee & Choi, 2011). Other researchers also found that students hope to gain international living experience and language skills while studying abroad during their time at university (Leong, 2015). In short, students decide to enrol and leave academic programmes for different reasons.

Because of the COVID-19 Pandemic and consequent recommendations for social distancing and related changes for teaching and learning behaviours (Dos Santos, 2020b, 2020a, 2020c, 2020e), almost all universities in the United Kingdom have developed different types of distance-learning platforms and materials. With some exceptions (e.g. student internships), on-campus, distance-learning, and international students have all been required to study their modules and programmes via distance-learning platforms. However, as previous studies (Lambert et al., 2017; Lee & Opio, 2011; Leong, 2015) have indicated, international students typically look to gain overseas experience and language proficiency during their study abroad experience. Because of this, it is important to understand why international students might like to complete their programmes via distance-learning.

Currently, most British taught master's degree programmes only require students to complete one year of full-time study to obtain a master's degree. Due to the global health crisis during the 2020 academic year, international students were more likely to complete their whole taught master's degree programme via distance-learning, without any on-campus learning experience. The main purpose of the current study was to gain understanding of the reason why these students decided to study completely online. Therefore, two research questions were established: 1) Why did these postgraduate students decide to complete their master's degrees completely online during the COVID-19 Pandemic? 2) How would these students describe the experience and decision-making process of pursuing a master's degree online?

1.1 Theoretical Framework

The study employed the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996) as the framework for understanding the motivation of the master's degree students who decided to complete their degrees completely online during the COVID-19 Pandemic. The Social Cognitive Career Theory was developed based on the Social Cognitive Theory of Albert Bandura (Bandura, 1988, 1992; Bandura & Adams, 1977). The latter theory is often adopted as a framework for a study when researchers seek to understand how internal intention and external factors influence the cognitive learning and decision-making process of individuals and groups. The Social Cognitive Career Theory adapted the ideas of Bandura's Social Cognitive Theory to investigate individuals' career development.

However, over the decades since the Social Cognitive Career Theory was developed, some behaviours, internal intentions, and external factors have changed. In order to meet the needs of contemporary individuals and groups, it was necessary to update some of the ideas and factors of the Social Cognitive Career Theory. Therefore, the current study utilized one of the latest versions of the Social Cognitive Career Theory developed by Dos Santos (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996). According to this version, individuals' motivations are influenced by four factors: career-related interests, performance and persistence in educational and occupational pursuits, academic and career achievements, and financial considerations. Each factor may interact with and connect to the other (Kwee, 2020). Therefore, individuals' motivation and career decisions may fall under one or multiple factors within the theory (see Figure 1 for the Social Cognitive Career Theory).

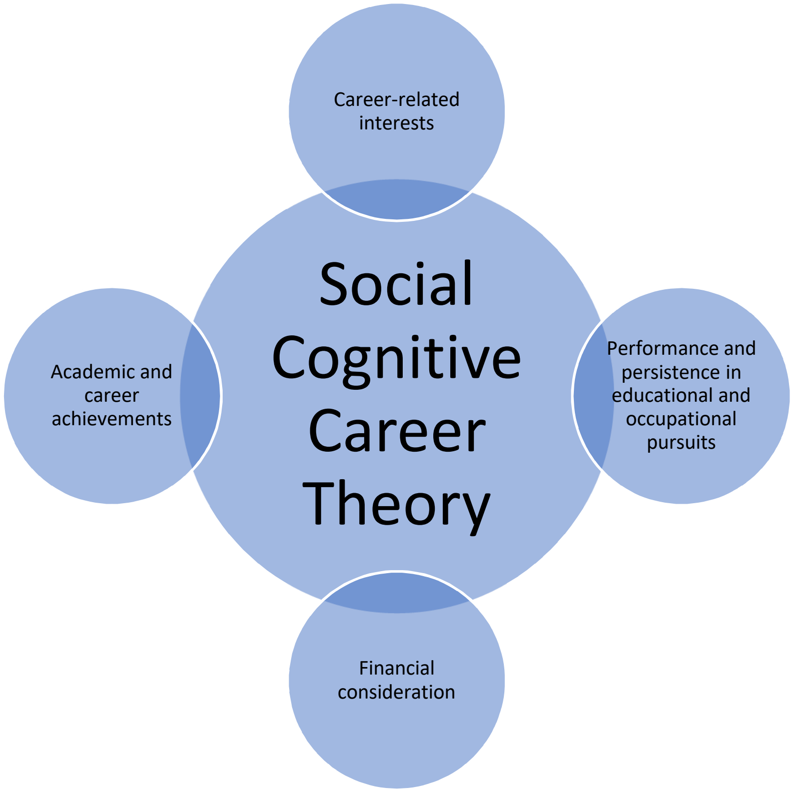

Fig. 1. Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996)

2 Methodology

The General Inductive Approach (Thomas, 2006) has been employed for the investigation. The current study collected data from a group of international students who decided to complete their taught master's degree via distance-learning in their home country (i.e. a location outside of the United Kingdom). In order to collect the wider feedback and voices from the participants, the researcher collected the data from multiple universities (i.e. do not limit to one single site and university). Therefore, the General Inductive Approach would be appropriate for a study without restrictions and guidelines, such as case study (Yin, 2012).

2.1 Participants and Recruitments

Based on the convenience and random sampling strategy (Merriam, 2009), the researcher collected data from 156 international students completing their taught master's degree programme at one of the British universities in their home country. The inductive surveys (Creswell, 2014) with both open-ended and semi-structured questions were employed to collect the comments and opinions about their motivations and reasons based on the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996). More importantly, the surveys sought to capture the information about 1) Why did these postgraduate students decide to complete their master's degrees completely online during the COVID-19 Pandemic? 2) How would these students describe the experience and decision-making process of pursuing a master's degree online?

The survey invitation web link was sent to the administrators of two British universities. The administrators distributed the weblink to their distance-learning taught master's degree students with the appropriate background. The weblink recipients were encouraged to forward the weblink/inductive survey to other potential participants who met the background. After four weeks, the researcher collected 156 valid inductive surveys.

2.2 Data Collection

156 inductive surveys were collected. First of all, the inductive surveys contained 20 open-ended and semi-structured questions, which required at least one paragraph-length comments. Almost all completed all the questions with appropriate answers. In general, the participants might use 30-60 minutes to complete the surveys. Second, after the researchers collected all the surveys, the researchers captured all the comments and opinions into the written transcript files.

As the surveys were contributed to all taught master's degree students who are currently studying at one of the British universities via distance-learning, the surveys were all written in English. Although the learners were allowed to use their own language(s), all surveys were answered in English.

2.3 Data Analysis

The researchers read the transcripts multiple times in order to capture the appropriate themes and subthemes for the study. First of all, the researchers employed the open-coding technique (Strauss & Corbin, 1990) to narrow down the massive materials into some orders and themes (i.e. first-level themes). However, researchers advocated that further engagements should be exercised. Therefore, the researchers employed the axial-coding technique (Strauss & Corbin, 1990) to merge the first-level themes into the second-level themes and subthemes (Merriam, 2009). As a result, the researchers yielded two themes and three subthemes for this study.

2.4 Human Subject Protection

The protection of participants' information is the most important factor in this study. Therefore, the researchers exercised all the potentials to protect the personal information of the participants. All the surveys, sensitive information, written transcripts, computer, and related materials were all stored in a password-protected cabinet. Only the researchers have the rights to read the materials. After completing this study, the researcher deleted and destroyed the related materials to exercise the protection.

3 Findings and Discussions

All participants answered the same survey with the same questions. However, their backgrounds, degree programmes, understanding, expectations, nationalities, and languages were different. As a result, their comments and opinions were diverse and meaningful. Based on the guidelines of the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996), the researchers were able to merge two themes and three subthemes (see Table 1).

Table 1. Themes and subthemes

Themes and subthemes
The Desire to Study for a British Degree
My Study Plan Cannot Be Delayed
Learning Outcomes Are the Same
Financial Considerations
Complete the Degree in One's Own Country: Save on Living Costs

3.1 The Desire to Study for a British Degree

All students decided to study for a British taught master's degree in order to enhance their knowledge, skills, and practices. Although distance-learning platforms necessarily limited the on-campus experience of these students, they accepted these changes given the circumstances of the COVID-19 Pandemic. More than 90% of the participants stated that the desire to obtain a British university degree was a primary influence in their choice to study. The different methods of learning (i.e. on-campus vs. distance-learning) did not affect their ability to learn. As several respondents commented,

> *…some students argued that online degree is useless…but online learning styles required additional focuses and self-disciplines…I don't think the learning style [distance-learning] will change my knowledge and learning outcomes…(Survey #34, Engineering)*

> *…a British degree is a British degree…distance-learning does not influence or impact the value of this meaningful degree…I learnt the knowledge from the materials…the outcomes and results are the same…I don't think people can challenge me at all…(Survey #86, Statistics)*

My Study Plan Cannot Be Delayed. Almost all students indicated that, for various reasons, they could not wait until the 2021 academic year to start their degrees. For example, a group of learners indicated that they wanted to begin doctoral programme(s) after obtaining their master's degree(s). Therefore, the current programme's learning style (i.e. distance-learning) did not impact their expected outcomes (i.e. a further three or four years of full-time study). Ultimately, these groups of students expected to return to on-campus learning after the COVID-19 pandemic and social distancing restrictions ended. Another comment from the survey was that,

> *...I will go back to the university on-campus for my PhD degree...this master degree year does not change...much of my plan...but if I decide to postpone my offer for a year...my plan can be changed as I have to go back to work...(Survey #33, Sociology)*

In accordance with the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996), the desire of respondents to obtain a British graduate degree was a primary deciding factor and one which could not be delayed. Furthermore, the fact that some participants planned to pursue a doctoral degree after their master's programmes indicated that their motivations to undertake graduate study were better-grounded than if these students had not planned on further schooling.

Learning Outcomes Are the Same. Before the COVID-19 Pandemic, many British universities offered distance-learning degrees and courses for domestic and international students, including The Open University, the University of London (International), and so on. (Rasheed, 2020). The transcripts and diploma a distance learner receives are no different than those on-campus students receive. More than 80% of the participants indicated that the status of on-campus and distance-learning degrees are the same. As two respondents commented,

> *...it is not uncommon for British students to complete their degree via distance-learning or online...the Open University, for example, offers an online degree in undergraduate and postgraduate level for decades...people use their online degree for work and job development...it is an excellent option for us to have this unique experience as online students...(Survey #12, History)*

> *...I am not studying a subject that requires student-internship...the online seminars, online training, online interaction with my tutors, and assignments are the same...we have the same syllabus and assignment lists as the on-campus students...we switch the platform to the online classroom...no differences can be found...(Survey #2, Anthropology)*

In short, many participants expressed that both on-campus and distance-learning degree programmes and courses are of the same status and quality—there are no differences between the two options. In accordance with the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996), the factor of academic achievement continued to guide the motivations of these groups of participants.

3.2 Financial Considerations

Besides students' desire to learn at a British university without the limitations of location and timeframe, financial considerations were another factor addressed in this study (Dos Santos, 2019a, 2019b). Although most universities have not reduced their tuition fees (as they continue to offer teaching activities and on-campus services, such as library and counselling services), many participants found that the distance-learning option(s) saved their resources significantly. One student commented,

…the university staff and tutors continue to provide excellent services to us…also, I can enjoy this service in my home at any time…I can talk to my librarian over the online platform…the university also needs to buy these services and online platform…I can feel my tuition fees and resources were used to the right locations and services…(Survey #76, Education)

Complete the Degree in One's Own Country: Save on Living Costs. Recently, the governments of some countries (e.g. South Korea) have decided to partially refund their students' tuition fees due to the COVID-19 Pandemic (Quinn, 2020). However, none of the participants endorsed this arrangement (i.e. refund): as schools had continued to offer services and teaching activities, participants believed the instructors and school staff deserved their full pay. Furthermore, they argued that as they live in their home countries, they are able to save a lot of resources. As one student commented,

As I can study in my home country and home city…I can save a lot of money…I am a teacher…I still need to work and pay for my living…I have a kid…my kid has teachers too…if we stop paying the tuition, how can the teachers and staff survive? Universities are usually non-profit organisations…they need money to survive…but some people just don't understand how teachers can survive with the minimum wage…(Survey #43, Education)

Another group of participants opined that by studying remotely, they could save on living costs, transportation costs, and personal expenses. Most participants stated that as the distance-learning option provided the same learning materials and quality of education, there were no incentives to return to campus (Sykes & Roy, 2017). Many stated that the high living costs in the United Kingdom, particularly in metropolitan areas, are among their biggest concerns. However, the distance-learning option allowed these participants to save their financial resources for further academic and career development (Dos Santos, 2020c, 2020d). As one participant commented,

…if I can receive the same education at a cheaper cost…I think completing the degree in my home country is a good option to save the living cost…as I can save the living costs in the United Kingdom for my PhD year…why not try this option…(Survey #103, British Literature)

In accordance with the framework of the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996), financial considerations served as the second factor in students' choosing distance-learning for their master's-level education. More importantly, many participants stated that as the school services and quality of education provided were the same for both distance and in-person learning, they were content to pay standard tuition fees without a discount.

In conclusion, this study's findings confirmed that both academic achievement and financial considerations served as two of the most important factors, as indicated by the Social Cognitive Career Theory (Dos Santos, 2020e; Lent et al., 1994; Lent & Brown, 1996). With the reflection of some previous studies (Garrison & Cleveland-Innes, 2005; Safford & Stinton, 2016; Siemens, 2005; Yukselturk et al., 2014), distance-learning options (during both the COVID-19 Pandemic and ordinary times) may offer the flexibility, potential for academic achievement, and feasible degree completion plans for traditional-age students, as well as non-traditional, returning, evening, and adult students (NTREAs), (Dos Santos, 2020b) to achieve their goals.

4 Conclusion and Implication

Although distance-learning courses and programmes are in the market for more than two decades, most students tend to complete their programme on-campus for various reasons, such as study abroad experience and language learning opportunities. However, due to the COVID-19 Pandemic, many universities decide to establish distance-learning courses and programmes temporarily and permanently to respond to the needs of their students, regardless of their geographic location and personal background. The development of distance-learning education may become one of the education trends based on the development of the curriculum plans and teaching and learning behaviours of both instructors and learners.

For the implication of the knowledge, the current study enhanced how these postgraduate students decided to complete their master's degrees completely online during the COVID-19 Pandemic. Study abroad and postgraduate education are not the compulsory requirements of most of the career developments and pathways. The results increased the knowledge about the development, motivation, and reason for these learners. The results further enhanced the knowledge about how these students described the experience and decision-making process of pursuing a master's degree online, particularly during the COVID-19 Pandemic. Although there were many studies about the teaching and learning behaviours and motivations of distance-learning students during the normal period, the current study filled the special era gaps during the early 21st century.

For the implication of the practice, school leadership, department heads, school counsellors, curriculum planners, and instructors may take this study as the opportunity to polish their current curriculum, plan, and teaching strategy to meet the needs of on-campus, blended, and distance-learning students. Although the on-campus teaching and learning directions will be resumed soon, the needs for distance-learning courses and programmes will be continued. Therefore, the developments and studies for distance-learning courses and programmes should be continued. Universities should not discriminate and ignored the needs of students with different needs. Otherwise, students will select other universities and programmes for their life-long development.

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Calm Amidst the Storm: Reflections and Predictions for Higher Education

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Abstract

Purpose – The COVID-19 pandemic has caused enormous pain and suffering, with the impact on health and daily life having been catastrophic. The impact on industry and professions has been severe, with many seeing widespread redundancy and closures. Although there have been silver linings — in the shape of resilience and adaptations, for example — the disruptions from COVID-19 have mostly been negative. Higher education (HE) is no exception, with many HE professionals losing their jobs, and others enduring stress and hardship to adapt to the emergency delivery styles of online teaching and learning (T&L). Individuals (and their institutions), under enormous stress, have had to quickly reevaluate their skills and strengths, addressing immediate and future challenges. This paper, drawing from over 20 years of HE experience, offers reflections on pre-pandemic approaches to HE practice, and predictions and analyses of post-pandemic HE life.

Design/methodology/approach – This paper is structured around reflections on various aspects of life for an academic professional, before and during the COVID-19 lockdown. Reflective practice, guided by autoethnography, and critical analyses of relevant literature form the main methodologies. The paper also includes (and addresses) informal and focus-group discussion surrounding the pandemic-related HE disruptions.)

Findings – In the face of increasing uncertainty, with so much stress at the individual, institution, and even sector level, it is easy to understand the pervasive pessimism reported throughout HE. However, although COVID-19 has changed HE, many of these changes had actually been predicted, and even advocated, before the epidemic. The COVID-19 online and blended T&L, microlearning, expanded use of OER, and many other innovations can be seen not only as emergency teaching strategies, but as opportunities for HE practice and professionalism to evolve. This paper highlights opportunities and other potentially positive outcomes from the current COVID-19 challenges.

Originality/value/implications – While many countries are still in lockdown, some (including China, the context for the author) are emerging and acclimating to the 'new normal.' Many of the disruptions caused by COVID-19 may actually have simply been expedited evolutions that many had anticipated, and even advocated. In addition to continuing reflective practice, and Kaizen-like (re)-evaluations, there are several clear opportunities now that HE educators and administrators should seize. In spite of the currently abounding stress and pessimism, there is reason for hope and optimism about HE's future.

Keywords: COVID-19, Microlearning, Mixed Reality, New Normal, Open Education Resources (OER), Professional Development.

1 Introduction

The recent world-wide lockdown in reaction to the COVID- 19 pandemic [1], [2], [3] has caused enormous disruption and suffering. Industry and professions have been severely impacted, and we have seen redundancies and closures in many sectors. Although there have been silver linings [4] — in the shape of resilience and adaptations, for example — the disruptions from COVID-19 have mostly been negative. Higher Education (HE) has not been spared, with many HE professionals losing their jobs, and others enduring stress and hardship to adapt to the emergency delivery styles of online teaching and learning (T&L). Individuals (and their institutions), under enormous stress, have had to quickly reevaluate their skills and strengths, addressing immediate and future challenges. This paper, drawing from over twenty years of HE experience, offers reflections on pre-pandemic approaches to HE practice, and predictions and analyses of post-pandemic HE life.

The paper is structured around reflections on various aspects of life for an academic professional, before and during the COVID-19 lockdown. These reflections are guided by reflective practice [5] and by the tradition of authoethnography [6], [7], [8]. They are also informed partly through critical analyses of relevant literature. The paper also includes (and addresses) informal and focus-group discussions surrounding the pandemic-related HE disruptions. A somewhat informal tone has been adopted throughout the paper, partly due to the methodological approaches employed, but mostly due to the subject nature of the paper and its intended (optimistic) message.

2 Background

2.1 Sino-foreign Higher Education

Xie et al. [9] have defined PRC HE as education conducted on the basis of completion of senior middle-school, and have described many PRC HE reforms as including projects to enhance PRC HE provision quality, including: Project 985, Project 211, and the C9 League [10], [11], [12], [13].

The PRC has also significantly opened up HE to foreign input, to also address both quality and quantity of HE provision. This has included Sino-foreign HEIs (SfHEIs), which are institutions created through partnerships between a Chinese and a foreign institution. In 2004, The University of Nottingham, in collaboration with the Wan Li Education Group, established the first SfHEI, University of Nottingham Ningbo China (UNNC). By 2019, according to Ma et al. [14], there were nine SfHEIs in operation, most of which involved a 985 or 211 project university as the Chinese host.

SfHEIs represented an innovative solution to the need to provide more HE opportunities, and, as well as thus being innovations, they are also often themselves hosts to innovative projects [15].

2.2 The author

I am an associate professor, currently serving as the Deputy Head of School for Computer Science (CS) at UNNC. I was also, previously, the Director of Teaching and Learning for CS. My background, previously described as something of an "academic mongrel” [16] includes qualifications in CS, linguistics, and education; industrial CS experience in several countries; teaching experience in kindergarten, primary, secondary, and postgraduate levels; and a number of administration and leadership roles in two SfHEIs.

When the COVID-19 situation first started developing in the PRC, around and shortly after December 2019, I was in China, but, through good luck, found myself in Europe for January and February of 2020. This was, it seems, when the initial disruptions in the PRC were escalating, but the rest of the world was not yet so impacted. I left Europe and arrived back at UNNC at the start of March, again, through good fortune, seeming to avoid the later COVID-19 problems in Europe, and getting into UNNC before the main lockdowns and severe international travel restrictions began. The PRC academic calendar is such that the Spring Semester usually begins after the Chinese New Year, and in 2020, this would have been late February [17].

Since my arrival back in March 2020, the UNNC semester start was postponed by several weeks, then delivered in an emergency online mode. This later switched to a blended form when, towards the end of the semester, some staff and students were able to return to campus for (parital) resumption of in-person T&L [18]. It is now over a year since then, and UNNC T&L appears to be mostly back to normal, with some differences and additional provisions for students (mostly international) who have not been able to return to campus.

Over the course of the past year and a half, since around the start of the COVID-19 pandemic, I have been part of, and have seen, many innovations and actions to address the impacts of the pandemic. In spite of the understandable stress and pessimism, there is reason for hope and optimism about HE’s future. I offer, in the following, some thoughts and reflections on this.

3 Reflections and Predictions

3.1 Designing and Planning Learning Activities

A “failure” may not be an obvious starting point for inspiring/innovative teaching, but for me it was critical.

Before joining UNNC, I had had experience designing and delivering many different study programmes, I was confident in my abilities, and eager to attempt to enhance the student T&L experience — by increasing student interaction through a flipped classroom [19], [20]. I planned an elaborate, semester-long plan that involved experiential learning [21], [22] and other unusual activities [23], with an aim of freeing up class time for more advanced activities [24].

The plan did not work [25], and its failure had a very demotivating impact on me. Fortunately, I was able to reflect on the experience and get advice and suggestions from both colleagues and students. I learned from this experience something that now guides all of my approaches to teaching: we should not assume that we know the best T&L strategies for students. I believe that we should involve them in planning, at all levels, as partners [26].

The switch to emergency online T&L, and later to blended delivery for both on-campus, in-person students and off-campus, online students, saw a large number of attempts to use new technologies, techniques, and tools [17] [18]. Much of this was untested, and resulted in additional complications and difficulties [4]. The users, including teachers and administrators, but also students, often had little to no prior training for these new modalities. Nevertheless, we tried, and we moved forward. Some amount of “failure” must be expected. But we must not become demotivated. We should reflect on what did work, why some things did not work, and what can be done to improve or enhance the situation. We should engage all the stakeholders, especially our students, to identify what is most likely to be most effective, and most appreciate. At UNNC, for example, we have seen some success with adopting microlearning [27], [28], [29], which involves providing learning opportunities to students in much smaller, bite-sized chunks. We have also seen T&L artefacts and provisions for off-campus students being adopted and embraced by students who are on-campus, including online office hours.

The pandemic has caused a lot of difficulty, but we have learned many things, and developed new skills and preferences. It will be essential that we leverage these skills and knowledge as we plan our future learning activities. Our students’ experiences and opinion will need to be included in our decisions about the design and planning for these activities.

3.2 Assessing and Giving Feedback

One of my main areas of practice and research, software engineering (SE) was, arguably, founded in the 1960s [30], as a call to apply the perceived rigour and methodologies of traditional engineering processes to the software development approaches then in fashion (which were, at best, *ad hoc* [31]). Thirty years later, the introduction of the now most widely-used approaches to software development, so-called Agile approaches [32], caused a fundamental change in how SE was perceived: Agile emphasized and embraced the critical role of feedback and iteration. Unlike the original metaphor underlying traditional SE, of being like a manufacturing process, the new metaphor became about “prototyping” — expecting that the product will need input and feedback from multiple stakeholders, iteration, and refinement. Figure 1 outlines a typical Agile approach to development.

When I first entered HE, SE education, unlike the industrial reality, did not seem to have many opportunities for students to receive formative feedback [34], and to iterate. Delivery and assessments seemed much more focused on the summative rather than formative roles [35]. Nevertheless, with the relatively small class sizes typical of 20-30 years ago, individual, personalised (*ad hoc*) feedback to students was possible. However, with the recent rapid increases in CS/SE popularity, we have been seeing much larger cohorts of students, with class sizes, and the associated workload, growing substantially [36]. This situation, even before COVID-19, had put great strain on CS T&L resources, in many cases rendering the individualised, personalised *ad hoc* feedback impossible.

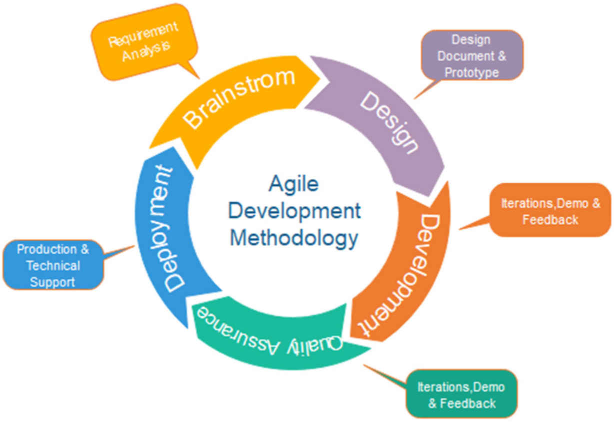

Fig. 1. Outline of Agile Software Development Methodology (from [33]).

In contrast to HE, some levels of teaching (for example, English and performance drama, from kindergarten to secondary schools) have much more explicit encouragement of students' confidence, though positive feedback. In a writing resources centre (WRC) at a different SfHEI, we included a process for student essay writing that required the student to have a peer (classmate) review the essay and give feedback; this reviewed essay would lead to a revision which could go to the WRC where native English teaching assistants (TAs) could give further advice and feedback; this WRC feedback led to a final iteration of the essay which, with the earlier iterations and earlier feedback attached, would be submitted to the course instructor. We found the quality of submissions to the WRC and to the course instructor improved dramatically, but we also found that the students themselves became more engaged in both the writing and peer reviewing process. A problem, however, was how subjective some of the feedback often was, especially from the peers. We later introduced a rubric system [37] that helped standardise the topics addressed in feedback, which also proved very popular with both the reviewers and the reviewed students. Overall, some key take-aways from this were: (1) peer and TA review were very effective at improving the essay quality [38]; (2) peer reviewing had a positive impact on the reviewer as well as on the reviewed student; (3) rubrics help enormously; and (4) associating marks (even very few) with the process seemed to communicate an importance that also had a positive impact on the process.

I have tried to draw from some of these experiences when designing assessment and feedback mechanisms for UNNC CS, and especially during our emergency and blended delivery over the past couple of years. Even before the COVID-19 pandemic, I had been exploring sustainable feedback mechanisms, especially for large cohorts [39].

Many aspects of CS assessment may naturally lend themselves to objective, standardized marking. Several years ago, when teaching an introductory programming class on Java, we used an automated grading and feedback mechanism. This alleviated a huge proportion of the marking workload, and also had a number of other advantages. We were able to completely standardise the marking for all submissions, across campuses, but we were also able to offer a scaled-down part of the automated marking to students so that they could get feedback on their work, make corrections, and iterate before their final submission. This functionality was very well received by the students, and led me to further explore its potential as a tool for flipping programming classes, and for supporting autonomous learners who my like to explore the quality of their own coding, independent of the coursework [40]. Another, similar project that has seen success with automated marking and feedback was deployed last semester for a databases class [41].

Moving forward, post-pandemic T&L will certainly require us to explore new tools and techniques, and to involve multiple stakeholders giving feedback. We will need to iterate, and improve, and learn. The feedback needed for better T&L should remind us of how important feedback is to our students. Although an ability to provide feedback at scale, such as through automation, will be increasingly important, the personalized feedback that may still be possible, and that seems so welcomed by students, is something that we must explore supporting further.

4 Conclusion

The COVID-19 pandemic has impacted enormously on life around the world. In addition to the immediate suffering caused by the disease itself, the subsequent lockdowns and other measures have also come at a cost. Higher education, like many other industries and sectors, has been impacted. Many individuals and institutions have faced significant challenges, including redundancy and closure.

The recent development and deployment of vaccines has begun to offer hope of an end to the pandemic, but lockdowns and other restrictions remain in place. Teaching and learning has had to shift to an emergency delivery mode, often online, or blended. Some places, such as the People's Republic of China, appear to have resumed mostly normal teaching. Even when more places resume face-to-face engagement, it is likely that we will continue to experience challenges. Many of the things that happened in response to the pandemic may actually have resulted in positive outcomes, and these positive things need to examined closely and built upon. Many of the skills we used before the pandemic have helped us during it, and may be the basis upon which to develop our practice, and support our students, in the post-pandemic world.

Acknowledgements

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Education in the New Normal: University of the Philippines Los Baños Students' Readiness for Remote Learning

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Abstract

Purpose – With the outbreak of COVID-19 in China which led the World Health Organization (WHO) to declare a global health emergency in March 2020, education has taken a new norm. The prevalence of remote learning has created a need to understand students' readiness for the new educational set-up. This study was conducted to assess the readiness of students for remote learning at the University of the Philippines Los Baños. It aims to determine the expectations of the students on a remote learning set-up, the challenges they face, and the assistance they need in order to recommend ways and interventions to address the challenges while ensuring an effective educational delivery through remote learning.

Design/methodology/approach – This study was conducted through a survey of 238 undergraduate and graduate student respondents. The remote learning readiness survey was adapted from the Online Readiness Assessment by Vicki Williams that consists of such areas as expectations, self-direction, learning preferences, study habits, learning strategies, language skills, technology skills, technology-mediated communication skills, and hardware/software requirements as the main basis for determining the readiness of the students for remote learning. In addition, a Likert scale with scores 1 (strongly disagree) to 4 (strongly agree) was used to determine the students' responses.

Findings – The results showed that the majority of the respondents strongly agreed on their expectation that a remote course is not easier than a face-to-face one; most were self-directed to finish what they had started; and more than half agreed on a learning preference that they learn well from auditory content. Similarly, the majority agreed to dedicate a specific time of the day or night to doing course work; to reflect on what they learned in every lesson; and to have confidence in their reading skills. For technology and technology-mediated skills, the majority of the respondents agreed that they are comfortable in navigating the internet and communicating via email and/or other synchronous means, while more than half agreed that they have a computer that runs reliably on Windows or Mac OS. Some of the challenges encountered were a poor/unstable internet connection; the financial cost of studying; too heavy an academic workload; proper time management; the unavailability of gadgets and internet data; difficulty in managing distractions; and anxiety and mental health issues.

Originality/value/implications – Faced with these challenges and difficulties, academic support, financial assistance, and support for mental health are some of the interventions proposed in the study.

Keywords: online learning, quality assurance, remote learning, student engagement, student satisfaction

1 Introduction

With the outbreak of COVID-19 in China which led the World Health Organization (WHO) to declare a global health emergency in March 2020, education has taken its new norm. The pandemic is "impacting millions of students worldwide and the number of students that will experience education disruption grows daily (Ray, 2020)."

Despite all the pandemic maladies, the pandemic disruption has brought awareness for new opportunities in reviving the educational system and ushering the students to a more inclusive, flexible, and compassionate teaching and learning experience.

In response to local confirmed transmission of COVID -19 in the country, the University of the Philippines (UP) had installed an academic contingency plan *(OVPAA Memorandum No 2020-31)* and resumed classes under the remote learning setup. Thousands of students across different UP campuses nationwide began the school year not in classrooms but in the safety of their homes (*Philippine Star, September 11, 2020)*.

Remote Learning occurs when the learner and instructor, or source of information, are separated by time and distance and therefore cannot meet in a traditional classroom setting (https://trainingindustry.com/glossary/ remote-learning). Information is typically transmitted via technology (email, discussion boards, video conference, audio bridge) so that no physical presence in the classroom is required. It provides an opportunity for students and teachers to remain connected and engaged with the content while working from their homes (Ray, 2020). Opportunities for remote learning are typically linked to emergency situations that pose a threat to student safety.

As cited by Yu & et al. (2015), it is necessary to provide support for learners in order to enhance their social competencies with instructors and classmates as well as their communication and technical competencies so that they can have a better learning experience.

One way to accomplish it is to gauge their readiness for online learning. Distance learners should be provided with an opportunity to develop their competencies or readiness skills to better avoid problematic situations involving non-content-related learning challenges that could prevent success in online learning. With this, the efficiency of transitioning to remote learning is dependent on readiness, technology tools, and overall student support infrastructure.

In a new educational set-up, it is important to determine the readiness of the students and the challenges it poses to students' learning. This study addressed the question of "how ready are the University of the Philippines Los Baños (UPLB) students in a remote learning set-up?".

1.1 Objectives of the Study

The general objective of the study is to assess the readiness of students in remote learning at UPLB. Specifically, it aims to:

1. Describe the profile of the student-respondents;
2. Determine the expectations of the students on remote learning set-up;
3. Determine the challenges encountered by UPLB students in remote learning;
4. Discuss the assistance needed by the students for remote learning; and,
5. Recommend ways and interventions to address the challenges.

2 Relevant Studies

Even before the onset of the COVID-19 pandemic, there have been a considerable number of studies published dealing with remote learning. The need for education especially caused by certain situations as evident with the transition to remote or online learning necessitates the evaluation of its effectiveness, hence the growing studies. Particularly at the present, there is increasing attention directed to remote learning in the context of a pandemic. In any event, there are still various matters that impact students on a remote learning set-up. This review explores studies on remote learning of students in general. Founded on this review, student's readiness for remote learning was then determined.

2.1 Modes of Delivery

In terms of remote learning, two modes of delivery are recognized namely synchronous and asynchronous. Synchronous learning is a method where learning is facilitated by media in the form of videoconferencing and chat (Hrastinski, 2008). Platforms such as Zoom and Google Meet are usually used. Asynchronous learning, on the other hand, is supported by media such as e-mail and discussion channels (Hrastinski, 2008; Owens, Hardcastle & Richardson, 2009). In an asynchronous set-up, learners and instructors are able to communicate at their own convenient time. However, another approach in remote learning that is gaining attention is blended learning. This concept was introduced by Graham (2006) and consequently described as the integration of both face-to-face and online elements. In the study conducted by Hsiao (2010) on the student's understanding of synchronous and asynchronous learning, it was concluded that while students acknowledged the pliability that the asynchronous method offers, they are also well-aware of the importance of real-time interactions. When compared to employing only one method of learning, a blended approach provides students an avenue for more effective learning (Zhao et al., 2005).

2.2 Barriers to Remote Learning

Remote learning poses several challenges to both the learners and instructors. This study acknowledges the importance of identifying these challenges. However, with its extensive scope as manifested in the relevant literature found, it is truly a hard task to come up with a substantial judgment. While numerous studies are focused on the instructor's experience, this specific study mainly looked into the learner's perspective. As such, the study utilized the remote learning readiness instrument by Padilla (2020) as adapted from the Online Readiness Assessment by Vicki Williams. This framework considers the following facets in gauging learner's readiness: expectations, self-direction, learning preferences, study habits, learning strategies, language skills, technology skills, technology-mediated communication skills, and hardware/software requirements. In addition, this study presents other relevant studies describing bottlenecks of students on remote learning which would later provide a solid ground for the analysis and discussion section of this study.

It is said that the learning of students is better facilitated if they actively take part in it (Intrator, 2005). However, with the shift to remote or online learning due to COVID-19, their participation is much more affected. Learners are left with anxiety that greatly affects them personally and academically. Huge demands are apparently laid down on the learners in an online environment when compared to the traditional one (Wolfe, 2000). Some may also have other matters on their hand such as working part-time jobs and shouldering other tasks at home. These circumstances increase student's stress and anxiety making schoolwork, not on their top list (Gillis & Krull, 2020). Even more so for those students who are from low-income families.

In the pilot study on the student barriers to online learning conducted by Muilenburg and Berge (2005), they identified six factors that affect students when it comes to online learning. These are (1) time/interruptions which pertain to student's time spent on online learning as well as the disturbances they encounter; (2) infrastructure/support services which refer to matters that the instructor could control; (3) motivation that include psychological issues to which students strive hard to overcome; (4) prerequisite skills which involve prior knowledge on a certain course; (5) technical that constitutes to the agreeable knowledge of students towards software/hardware system in online learning; and lastly, (6) social which relates to the favorable environment students should have. They, later on, made some modifications to these factors and settled on a total of 47 for their main study. Of these barriers, they pointed out that the most significant barrier to students in an online learning set-up is the lack of social interaction. Interaction is defined as "the learner's engagement with the course content, other learners, the instructor, and the technological medium used in the course" (Thurmond, 2003 as cited in Thurmond & Wambach, 2004). Chickering and Ehrmann (1996) further stated that interaction has crucial functions and among these include the promotion of contact between learners and instructors, initiation of collaboration, facilitation of active learning, and delivery of prompt assessment. Similarly, Gillis and Krull (2020) observed in their study that students this pandemic time suffered considerable hurdles in their learning. These include distractions, greater anxiety, and reduced motivation. They also noted that the Internet and technology are prevalent among these barriers. The importance of student's interaction with their teachers as well as their classmates were mentioned as well. But this did not necessarily mean the general approval of students when it comes to communication tools such as Zoom.

Nevertheless, the study of Muilenburg and Berge (2005) only basically revolved around the "lacking" side concerning distance learning in general. The same goes with the study of Gillis and Krull (2020). The studies were not able to address other substantial aspects such as learner's preferences and strategies in coping with this kind of learning set-up. Thus, this study helped close the gap by gauging the actions or plans of learners as they undergo remote learning.

3 Definition of Key Terms

Remote Learning- occurs when the learner and instructor, or source of information, are separated by time and distance and, therefore cannot meet in a traditional classroom setting, information is typically transmitted via technology so that no physical presence is required.

Readiness - is expressed as time management, self-guidance skills which is on the nature of online learning, adopting the internal resources of motivation, recognition of personal learning style, and experiences.

Expectations- understanding learning is a student’s responsibility and a remote course is not easier than a face-to-face course.

Self-direction – understanding the learning needs of individuals, setting goals and deadlines, creating learning objectives, and take responsibility for self-learning.

Learning Preferences – learning by reading, from auditory content (lectures, recordings, or podcasts), on his/her own, can work well in a virtual classroom (Learning Management System)

Study Habits – can dedicate specific time to do coursework, can ignore distractions, and willing to spend 5-10 hours each week

Learning Strategies – use strategies (notetaking, summarizing) and reflect on what he/she learns in every lesson.

Language Skills – confidence in reading and writing skills.

Technology Skills – comfortable working with different applicants on a computer or laptop, navigating the Internet, and can download files and attachments.

Technology-mediated Communication skills – comfortable in communicating via email and /or other asynchronous means, and synchronous audio/video interactions using applications (Messenger and Viber) and platforms (Zoom)

Hardware/Software Requirements – have a computer that runs reliably on Windows or Mac OS, have internet access with good use strategies (notetaking, summarizing) and reflect on what he/she learns in every lesson.

4 Methodology

4.1 Research Instrument and Data Analysis

The study employed an online survey via Google form for UPLB Students to obtain the socio-demographic characteristics of the respondents and to determine the readiness and challenges encountered in remote learning.

The questionnaire contained statements from the remote learning readiness by Padilla (2020) as adapted from the Online Readiness Assessment by Vicki Williams namely: *expectations, self-direction, learning preferences, study habits, learning strategies, language skills, technology skills, technology-mediated communication skills, and hardware/software requirements* were use as the main basis of determining the readiness of the students in a remote learning set-up. Using the Likert scale of scores 1 (strongly disagree) to 4 (strongly agree), the readiness of the students was determined. Also, the student-respondents were asked what were their preferred learning management systems (LMS), challenges they encountered in remote learning, and assistance they needed for remote learning.

Frequency counts, percentages, and mean scores were then computed for the analysis of the obtained responses. To analyze student's comments on remote learning, the qualitative responses were analyzed from the recurrence of the common responses. The resulting data was then used to support details for the form precise conclusions.

5 Results and Discussion

5.1 Profile of the student-respondents

Participants in this study were composed of undergraduate and postgraduate students studying at the University of the Philippines Los Baños, Laguna, Philippines. There were a total of 238 UPLB students who participated in the survey. As seen in Figure 1, there were 86 (36.1%) male and 152 (63.9%) female respondents.

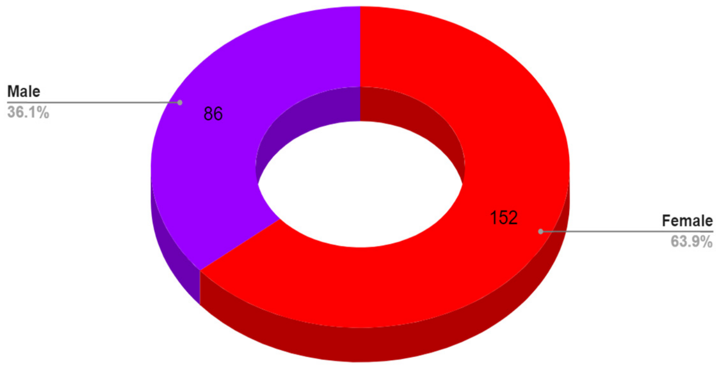

Figure 1. Distribution of Respondents by Sex

Correspondingly, Figure 2 shows that 140 or approximately 59% of the respondents have graduated from a public high school while 98 or 41% were from private.

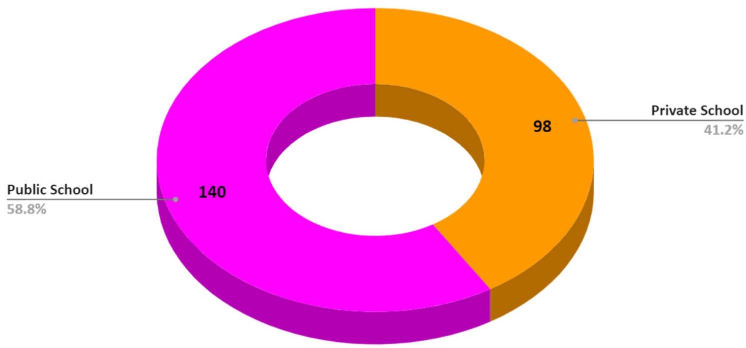

Figure 2. Distribution of the Respondents by Type of High School Graduated From

Table 1 also shows the socio-demographic information about the respondents. In addition to the aforementioned, the level of education of the respondents was also asked. There were a total of 203 (85.3%) undergraduate students while the remaining 35 (14.7%) were taking postgraduate courses. For a further breakdown of the former, 44.5% were freshman, followed by senior (17.2%), junior (16.9%), and lastly, sophomore (6.7 %).

Table 1. Summary of the Socio-demographic Profile of the Respondents (n=238)

Socio- Demographics	Total	
	No.	%
Sex		
Male	86	36.1
Female	152	63.9
Total	**238**	**100.0**
Level of Education		
Undergraduate	203	85.3
Freshman	106	44.5
Sophomore	16	6.7
Junior	40	16.9
Senior	41	17.2
Postgraduate	35	14.7
Total	**238**	**100.0**
High School Graduated From		
Public High School	140	58.8
Private High School	98	41.2
Total	**238**	**100.0**

Gauging the readiness of learners on remote learning helps the instructors and the institution as a whole on what kind of approach and adjustments are necessary to provide learners an effective education. Thus, this particular study aimed to determine student's readiness by employing the remote learning readiness by Padilla (2020) as adapted from the Online Readiness Assessment by Vicki Williams. Expectations, self-direction, learning preferences, study habits, learning strategies, language skills, technology skills, technology-mediated communication skills, and hardware/software requirements were considered and a 4-point Likert scale was utilized.

5.2 Remote Learning Readiness of Students

5.2.1 Expectations of the students on remote learning set-up

Based on Figure 3, almost all of the respondents (98.7%) understand that learning is their responsibility. Majority (98.3%) agreed that they understand that a remote course is not easier than a face-to-face course while the majority (98.4%) also understand that they will interact and work with people they might never see in person. The findings of this study are consistent with the views of Pendoley (2019) and Carpenter and Pease (2013) that students should take more responsibility for their learning. Recognizing that learning is one's own responsibility translates to one being able to devote time, energy, and effort to attain knowledge while knowing that instructors are merely on the side for guidance. The majority of the students who participated in this study clearly acknowledged this. This despite considering that remote learning is much more challenging than the traditional one. These may have arisen due to the number of barriers presented earlier in this study, one of which is the lack of social interaction. Students understood the fact that they could communicate with other students that they might never see in person. Thus, face-to-face interaction is put to a minimum on a remote learning set-up. With the apparent limitation in interaction comes the significant impact on the student-teacher relationship, student-student relationship, and student's active participation as well as evaluation as noted in the study of Chickering & Ehrmann (1996) and Gillis and Krull (2020).

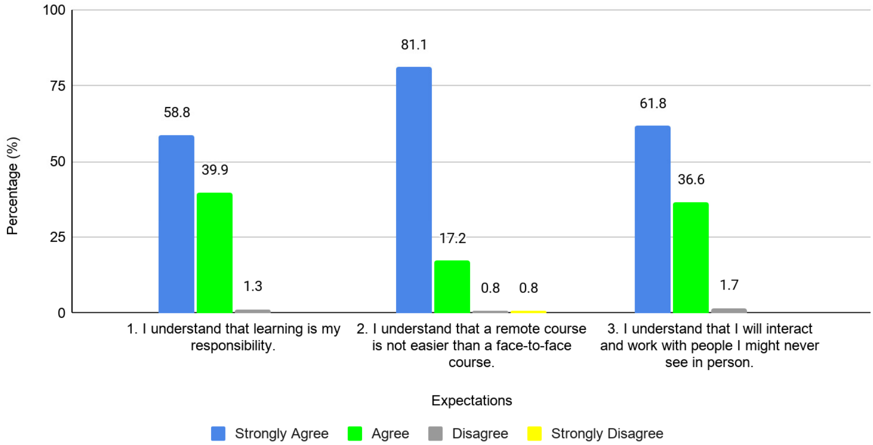

Figure 3. Percentage distribution of the level of agreement of the respondents on their expectations towards remote learning

5.5.2 Self-Direction

Meanwhile, self-direction (SD) suggests independence but is further defined as the "capabilities of people to direct their own lives based on their understanding of themselves, others, and the world, and their skill in managing their own learning, motivation, and behavior" (Squier, 2021). One subconstruct of SD is self-directed learning (SDL) which pertains to the "students' perceptions of their independent learning, their sense of responsibility in their learning and their initiative in learning" (Geng, Law & Niu, 2019). As such, when it comes to the learner's self-direction (SD), Figure 4 showed that the majority (71.9%) agreed that they are good at setting goals and deadlines for themselves. The majority (92.5%) had likewise said that they finish what they started. Lastly, more than half (64.3%) agreed that they could keep themselves on track and on time. The result comprehensively implied that the majority of the UPLB students surveyed could undergo self-directed learning and can be considered self-sufficient when it comes to thinking and behavior.

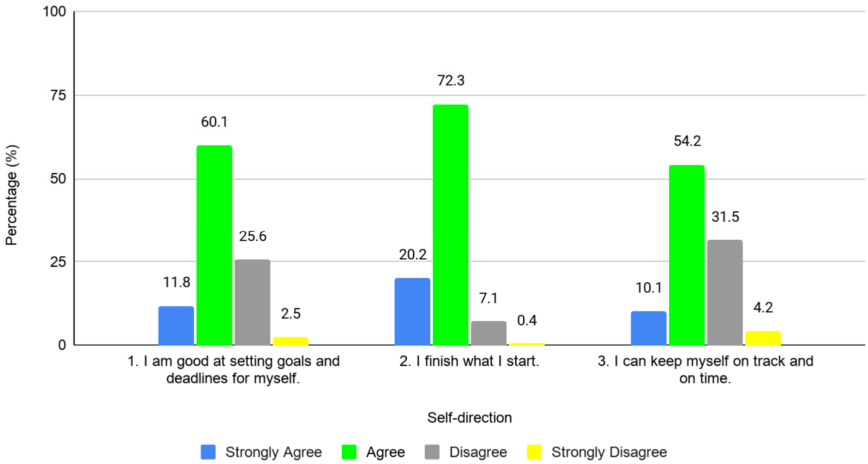

Figure 4. Percentage distribution of the level of agreement of the respondents on their self-direction

5.2.3 Learning Preferences

On the other hand, the learning preferences of the respondents were also assessed. As seen in Figure 5, almost 65% of the respondents agreed that they could learn well by reading. In the same manner, 93.3% of the respondents stated that they could learn well from auditory content such as lectures, recordings, or podcasts. The present study found out that students surveyed generally have their own varied learning preferences. As noted in the study of Khan, Arif, and Yousuf (2019), college students are mainly inclined toward visual learning as their learning preference. Auditory comes only second. The last would be the combination of both visual and auditory. Even though more than half of the respondents (52.6%) said that they could learn well on their own and 60.9% of them relatively concurred when asked if they could work well in a virtual classroom within a learning management system (like the MOODLE in the ILC e-learning Based Instruction Site), the learning preferences and eventually the learning styles have to be considered first. Moreover, Mkonto (2015) emphasized that students being aware of their learning preferences helps them develop certain learning potentials which enable them to decide on the most appropriate learning styles. Correspondingly, identifying the learning styles of learners is especially crucial for instructors in determining the most suitable teaching styles on a remote learning set-up.

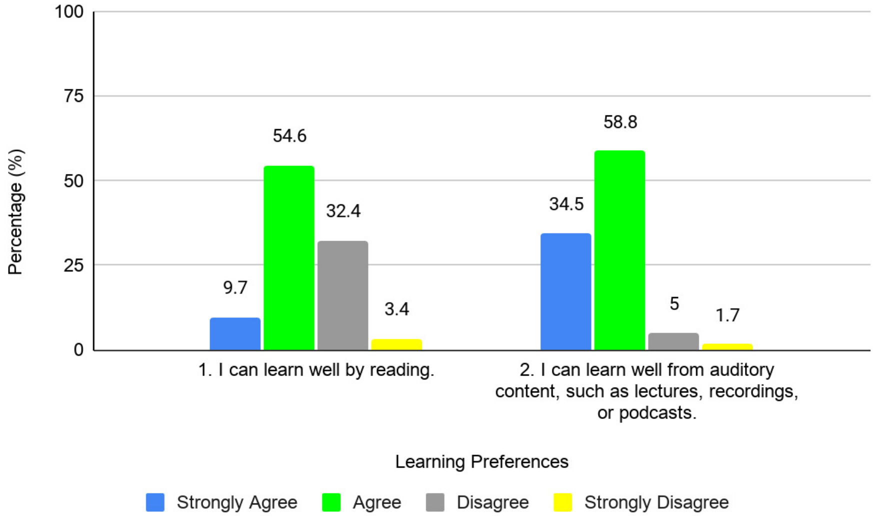

Figure 5. Percentage distribution of the level of agreement of the respondents on their learning preferences.

5.2.4 Study Habits

Gaining an insight into the student's study habits, the results of the study are presented in Figure 6. As one of the significant elements in assessing a student's readiness for distance learning, study habits include various activities such as time management. The results revealed that the majority of respondents (87.8%) asserted that they could dedicate a specific time of day or night to do their course work and more than half (76.5%) also agreed that they are willing to spend 5-10 hours each week on a remote course. Study habits do not only refer to the student's manner of studying but are also connected to the student's learning preferences, learning styles, and learning strategies (Çakıroğlu, 2014). Considering the first two study habits mentioned in this particular study, the majority of the students surveyed could be seen to have positive study habits. As Çakıroğlu (2014) further stated, positive study habits have a significant relationship with average scores. However, there are also negative study habits. Evidently, more than half of the respondents (63.5%) expressed that they could not ignore distractions around them when they study. Though this may not appear as an intentional bad study habit, this finding confirms the views of Muilenburg and Berge (2005) and Gillis and Krull (2020) who cited distractions as one of the barriers in student's remote learning. Distractions can come in different forms such as technology-based (gadgets and social media), work and family commitments (Winter, Cotton, Gavin & Yorke, 2010), external (unexpected noise), and among others.

In addition, Somuah, Dankyi, and Dankyi (2014) brought up in their study that distant education learners manifest other study habits such as "reading while lying in bed, not being able to study for a minimum of three hours in a day, do not look for additional materials from the internet as well as reading over their notes before their next face-to-face meetings".

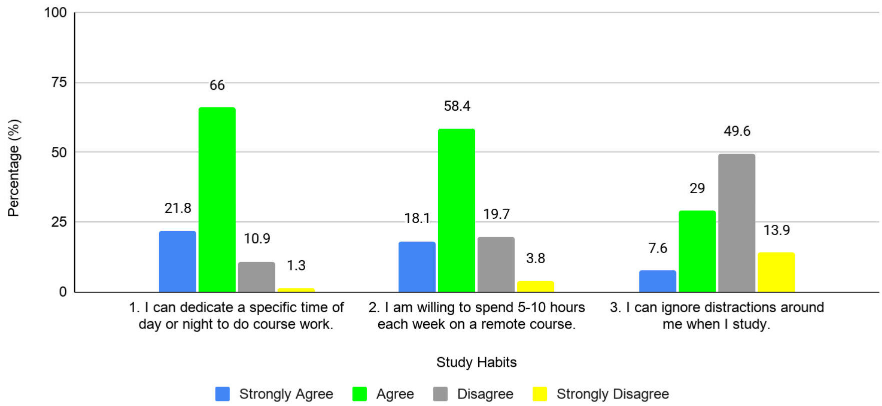

Figure 6. Percentage distribution of the level of agreement of the respondents on their study habits.

5.2.5 Learning Strategies

With regard to the learning strategies, the results as shown in Figure 7 depicted that 91.6% of the respondents use strategies (like notetaking, summarizing) to help them learn. Similarly, the majority of them (82.3%) agreed that they reflect on what they learn in every lesson. As discussed previously, learning strategies are closely related to learning preferences and study habits (Çakıroğlu, 2014). Proctor et al. (2006) even mentioned that utilizing suitable note-taking strategies as well as carefully selecting a convenient environment for studying are considered activities relating to study habits. As evident with the results, it can be said that students who participated in the study universally employ adequate learning strategies.

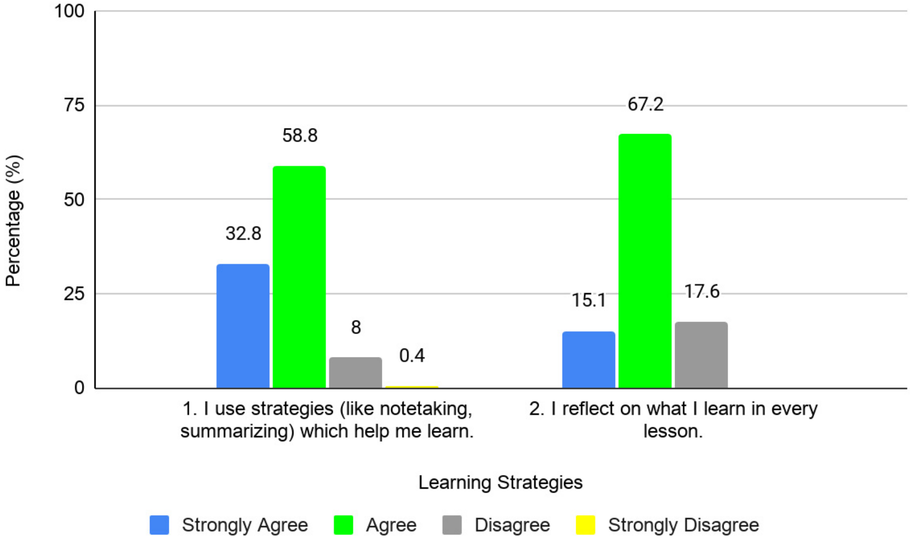

Figure 7. Percentage distribution of the level of agreement of the respondents on their learning strategies.

5.2.6 Language Skills

On the other hand, Figure 8 illustrates the distribution in respect of the respondent's language expertise. When asked if they are confident with their reading skills, more than half (79.4%) plainly asserted. In the same fashion, 73.1% of the respondents expressed their confidence in terms of their writing abilities. Since all the respondents were having their tertiary education, it is safe to assume that their language skills are satisfactory. However, some students might have encountered problems that challenge their language skills. As noted in the study of Milad (2017), some of these bottlenecks include the low proficiency level of students due to their limited English knowledge as well as learning potentials which prevent them from working on their reading and writing skills. Another reason is the mediocre output of students brought about by constraints in time and tasks from other courses that restrict them from allocating sufficient time on gathering pertinent data for their essays. It is worth noting that these problems were encountered on a traditional set-up. The scenario could probably be different in a remote learning arrangement.

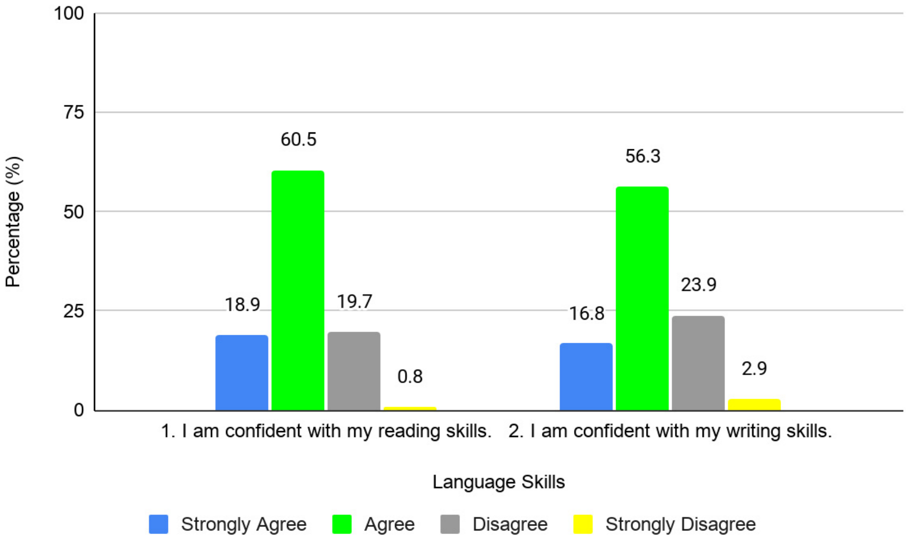

Figure 8. Percentage distribution of the level of agreement of the respondents on their language skills.

5.2.7 Technology Skills

As for the technology skills, Figure 9 shows that the majority of respondents (80.6%) stated that they are comfortable working with different applications on a computer/laptop. Also, 89.9% of the respondents conveyed that they are comfortable navigating the internet. One distinct characteristic of the current learners, which are called the ilearners or the Generation Z learners, is their affinity and knowledge about a fast-evolving technology. This finding is also expected since these Gen Z representatives who are also a product of the K-12 program have never seen the world devoid of the internet and thus have an affinity for texting and messaging on mobile apps or online platforms, sometimes even over in-person, face-to-face communication. According to the Generation Z facts sheet, 44% of teens use computers to do their homework. Furthermore, 48% of teens watch how-to videos that are related to school (Robertson, 2018). Fortunately, only a few respondents (3.8%) differed when it comes to downloading files and adding attachments. Although it can be said that students surveyed in this study generally express confidence when it comes to using internet-related technologies, there are still those few who were not.

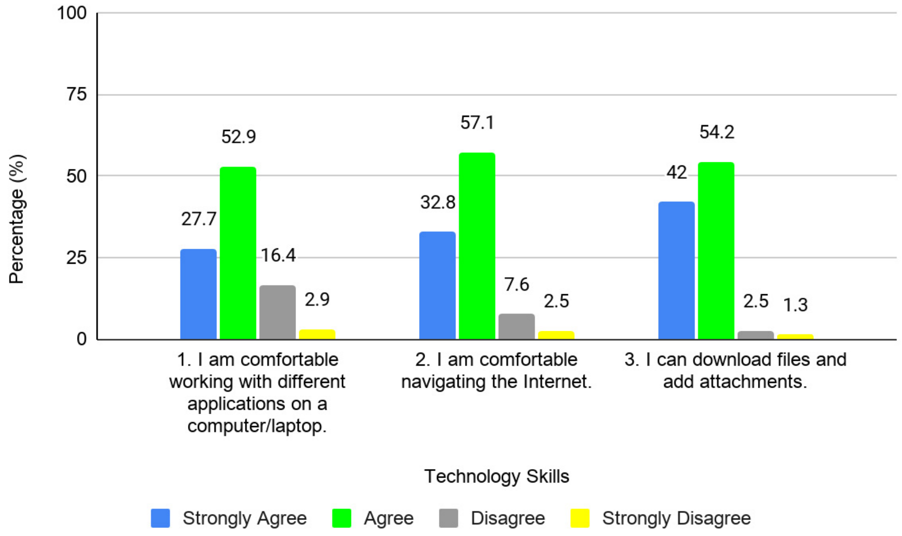

Figure 9. Percentage distribution of the level of agreement of the respondents on their technology skills.

5.2.8 Technology-Mediated Communication Skills

In relation to the technology-mediated communication proficiency of the respondents, results as presented in Figure 10, revealed that majority (83.2%) said that they are comfortable communicating via email and/or other asynchronous means. In the same fashion, more than half (77.7%) said that they are comfortable with synchronous audio/video interactions using applications (like Messenger and Viber) and platforms (like Zoom). Despite these satisfactory results, just like with the technology-skills results, there are still a number of students who were not comfortable. These findings are in line with that of Owens, Hardcastle, and Richardson (2009). In their study which also included undergraduate and post-graduate students, students with limited knowledge of communication technologies were found to be the most dissatisfied. Nearly all students preferred printed materials as back-up. This may be because of the delays they encounter in getting connected due to technological difficulties.

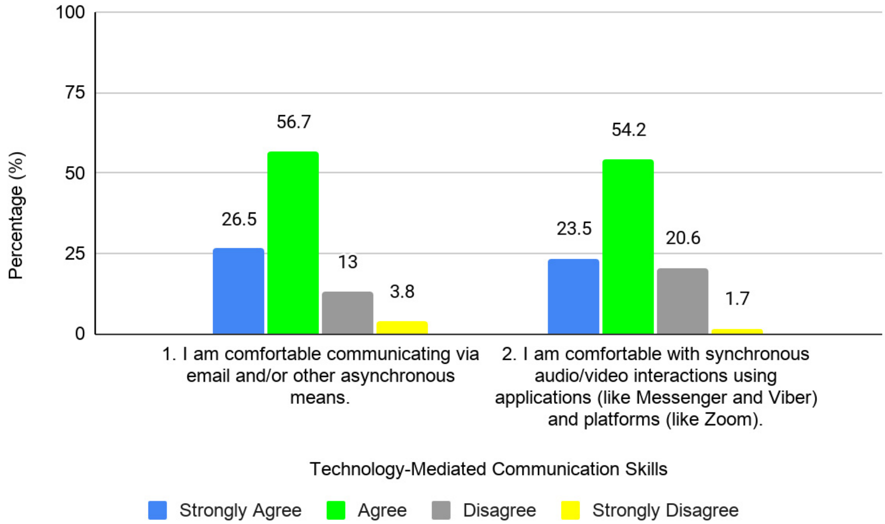

Figure 10. Percentage distribution of the level of agreement of the respondents on their technology-mediated communication skills.

5.2.9 Hardware/Software Requirements

As seen in Figure 11, when it comes to the required hardware/software, the majority of respondents (86.5%) claimed that they have a computer that runs reliably on Windows or Mac OS. However, only 60.5% of the respondents have Internet access with a good, and reliable connection. The results of the study showed that there are a number of students who do not have stable internet connection. Gillis and Krull (2020) noted that internet and technology barriers are the common struggle of students. With the demand of remote learning comes an unspeakable pressure on financial stability, particularly for students from low-income families. Evidently, this particular study found out that only 53.4% of the respondents have (access to) a printer. This is an indication that students find difficulty in accessing technologies especially during this pandemic-stricken time where many internet shops are not able to operate.

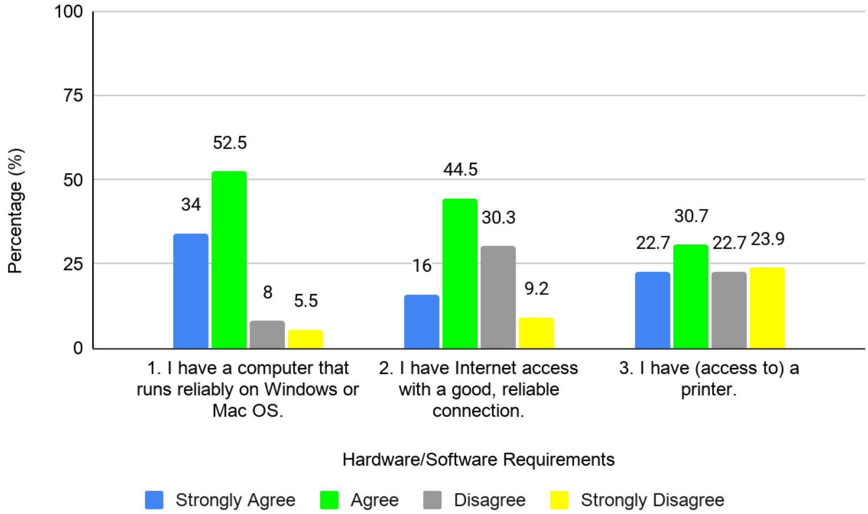

Figure 11. Percentage distribution of the level of agreement of respondents on hardware/software requirements.

5.3 Preferred Learning Management System (LMS)

When the respondents were asked about their preferred LMS, more than half (68.5%) mentioned learning application software such as Google classroom, Moodle, and Edmodo. Some also indicated video conferencing platforms such as Google meet and Zoom. Meanwhile, 31.5% of the respondents gave other responses and reiterated face-to-face as well as blended learning several times. Academic freeze was also included as a response. Moreover, quite a few said that they do not know what is an LMS while others answered not applicable.

Table 2. Distribution of the Preferred LMS of Respondents.

Learning Management System	Total	
	No.	**%**
Google Classroom/Moodle/Edmodo/ Google Meet/Zoom	163	68.5
Other Responses Face-to-face Learning Blended Learning Academic Freeze I don't know [what is an LMS] N/A	75	31.5
Total	**238**	**100.0**

5.4 Challenges encountered by UPLB Students in Remote Learning

The students were asked about their biggest challenges as they go on remote learning. A great deal of concerns were raised and the study observed a number of general issues. First on the list is the inaccessible or unstable internet connection. Several students were particularly concerned with this since some were in areas where the internet is not available or hard to access and power outages are prevalent. Following other similar studies, indeed, one of the struggles which affect students in focusing on their online lessons is due to technological problems (Gillis & Krull, 2020; Owens, Hardcastle & Richardson, 2009). As also noted in the study of Geng, Law and Niu (2019), technological readiness of students has a considerable impact on their learning effectiveness. Moreover, technological struggle is seemingly an overarching term which boils down to various specific concerns that were also brought up by the students. Few students mentioned that they were lacking in terms of technical skills as well as resources. Gadgets and internet data were particularly cited as barriers which could be attributed to their financial instabilities. Accordingly, financial costs of study puts substantial strain on students' psychological being; they experience an increased state of anxiety (Gillis and Krull, 2020) and stress. Adding to these are the numerous distractions such as noise from the neighbours, social media/gadgets, and personal and household responsibilities/problems. These findings are further supported by that of Winter, Cotton, Gavin and Yorke (2010) which concluded that personal technologies such as mobile phones and non-learning applications cause unnecessary disturbances to students and likely to have an impact on students' academic performance. Besides lack of interaction or reduced communication with instructors and fellow students and preference on blended learning, among other definite bottlenecks identified through the study include issues on time management (failing to meet deadlines), instructor's capabilities in handling remote learning courses, heavy workload/requirements, inadequate library and journal resources and natural calamities such as typhoons.

5.5 Assistance needed by the students for Remote Learning

Consequently, the study noted down the assistance needed by the students. Several students cited financial support. Being in a premier university does not necessarily mean that students are free from financial struggle. Even more so during this pandemic where the unemployment sector is hit hard by the prevailing economic crisis. The students were having a hard time adjusting to the situation particularly those who belong to low income families as they strive to have access to a stable internet connection as well as functional gadgets such as smartphones and laptops. Moreover, students mentioned psychosocial support. Consistent with the challenges previously presented in this study, students actually experience anxiety and stress throughout their remote learning that prompt them to write as such. One student even commented, "moral support/encouragement from professors would be appreciated". This statement only proves that instructors play a crucial role not just in student's learning but also in their well-being especially during this uncertain time. Other varied specific responses include flexibility on deadlines (more compassion), academic ease, more asynchronous class and less academic requirements.

In response to these, the UPLB through the Office of Scholarships and Grants (OSG) under the Office of the Vice-Chancellor for Students Affairs (OVCSA) have implemented various assistance programs under the Grants-In-Aid Program to bonafide and currently enrolled students. These include the Student Learning Assistance System (SLAS) Online, the Universal Access To Quality Tertiary Education (Free Tuition) Act and the Iskolar ng Bayan.

With the Grants-in-Aid Programs, “students who are no longer covered by free tuition fees, and in some cases, acquire additional financial assistance through monthly stipends. Starting academic year 2020-2021, the assistance has extended to providing students with learning assistance in support of the remote learning arrangement of the university as classess resumed during the ongoing COVID-19 pandemic. Students from vulnerable households are able to apply for assistance in the form of internet connectivy subsidies and gadgets.”

Furthermore, in support of remote learning, the university is providing academic support to college students who would apply for learning assistance through the SLAS. Students from low income households shall received monthly internet connection to support academic instruction and learning activities this academic year. Based on student’s updated application information, students from the most vulnerable families shall be offered gadgets on top of their internet connectivity subsidy. To expand the support to financially challenged students, UP launched the

Kaagapay sa Pag-aaral ng Iskolar ng Bayan Program. It has "mobilized the private sector to donate cash and in-kind gadgets that will be made available to those who applied for learning assistance."

6 Conclusion

The objective of the study was to determine the remote learning readiness of students at the University of the Philippines Los Baños, Laguna, Philippines. It revealed that UPLB students generally recognize that learning is one's own responsibility and that remote learning is not in any way easier than the face-to-face arrangement. They also showed confidence to undergo self-directed learning despite a handful of disadvantages. There are still barriers that prevent them from being fully prepared in undergoing remote learning. The latter was thoroughly discussed through the concept of challenges or barriers. Among these include technological problems, distractions, psychological burden, financial struggle, reduced social interaction and juggling personal responsibilities. Subsequently, the study concluded that several students are in most need of financial/technological assistance and psychosocial support. In support of remote learning, UPLB have provided learning assistance through the Grants-in-Aid program. It includes financial support for internet connectivity subsidies and gadgets to students from the most vulnerable families.

In the future, this study could probably be furthered by also taking into account the perspective of the instructor or the faculty-in-charge in order to create more effective learning and teaching strategies that would help in enhancing student's readiness towards remote learning.

7 Recommendations

Based on the findings of this study, the following recommendations are forwarded:

1. In relation to the various challenges to remote learning, it is suggested that a regular assessment on the student's as well as the faculty's situation should be done so as to create opportunities for possible interventions i.e. improvement of learning/teaching methods, psychosocial support, financial/gadget assistance, technical support, among others.

2. Aside from the provision of financial assistance programs of the Office of Scholarships and Grants under the Office of the Vice-Chancellor for Student Affairs, the Office of Counseling and Guidance also under the OVCSA should continue to be proactive in providing guidance and counselling services (psychosocial and emotional support) as the cases of mental health issues on students are more prevalent due to the challenges faced in remote learning. Support in the implementation of their programs and activities

should continue be provided, be it in the form of financial or human resources.

3. The Interactive Learning Center (ILC) should continue providing technical assistance both to faculty members and students on the management of learning management system particularly on MOODLE, specifically, in the creation of account and access to e-courses in the university. In the same manner, ILC should also continue providing regular online training workshops to capacitate the faculty members and other teaching personnel on e-learning practices, support of innovative teaching and learning strategies, and develop the digital skills and capabilities of participants on interactive teaching and learning. Additionally, access to interactive learning materials on various topics must be available online as supplementary learning materials that will help enhance student's learning. Support on the development and production of interactive learning materials must be also sustained and promoted actively to faculty members. Having adequately prepared faculty would redound to more efficient delivery of courses through remote learning.

4. The various student support services in the form of webinars and shorts talks, among others, provided by Learning Resource Center (LRC) have been beneficial not only to the learning needs of the students but also to its various stakeholders. It is hoped that they would continue providing these services as support mechanism in addressing the academic support requirements of the students and professional needs of the faculty and other stakeholders.

5. As for the study itself, the identified barriers to remote learning were not further explored since the study only utilized a 4-point Likert scale. It would have been advantageous if each statement is followed by probing questions to obtain in-depth response from the students. Qualitative approaches such online interviews or online focus group discussions could complement the quantitative survey conducted. This is an area that needs further exploration in similar studies in the future. A follow-up study by the authors is now under conceptualization stage.

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E-learning Practices in the Pre-pandemic Phase: Impacts on the Teaching Practices in Higher Education in the Macau SAR

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Abstract

Purpose – The 21st century has been marked by several transformations. Technological evolution, the most obvious one, has been used to improve various social domains, in particular contemporary pedagogical experiences and innovative practices. Also, since the current COVID-19 pandemic began, it has never seemed as relevant as now to shift away from outworn rote educational practices. However, with distance learning becoming the 'new normal' in many parts of the globe and having COVID-19 as an inflection point for innovation in the e-learning paradigm, the fragilities an unplanned and rapid shift to online learning bring to the learning and teaching experiences of this nature may also result in the reduction of significant learning and holistic teaching practices, that new fundamental on pedagogies, in harmony with social constructivist theories, have been trying to ensure in the open education movement.

These vulnerabilities — mostly marked by the lack of training, insufficient understanding of the distance education domain, and little preparation — had already been explored, prior to the pandemic in a 2019 case study about e-learning and the integration of emerging pedagogies in two institutions of higher education (HE) in the Macau Special Administrative Region (MSAR). The questions interconnected with the research are as follows:

(1) What technologies are being used in the context of higher education teaching/learning by its teachers?
(2) What is the teachers' 'digital profile'?
(3) What is the impact on students when they adopt e-learning practices in higher education?
(4) What are the teachers' e-learning practices?
(5) What are the reasons behind the adoption of certain technologies in higher education teaching practices?

Design/methodology/approach – In this study — which aims at outlining an authentic representation of the dynamics and pedagogical practices of e-learning in two distinct institutional realities — patterns of technological integration in the teaching-learning process, teaching staff digital skills, and methodologies for technological adoption were closely analysed through a structured questionnaire which was filled in, anonymously and confidentially by higher education teachers. The survey focused on the intersection of four axes that combined the problem with the research purposes. A selective blend of qualitative and quantitative approaches was integrated into this research.

Findings – The major findings of the study indicated that, overall, the technology being used in these institutions alluded merely to the support of pedagogical practices and were not being incorporated in a significant emerging way. Institutional support and development of such practices were also determined to be inefficient, while concepts of openness were revealed to be not only underdeveloped but typically misapprehended by the participants and institutions.
Originality/value/implications – The research and scope of the study provide valuable insights into the e-learning scene in Macau, which led to the outlining of a feasible preliminary framework on e-learning practices being developed/implemented in MSAR higher education, as well as an accurate digital profile of the teaching staff in the said level of education. Suggestions and recommendations were offered which were intended to improve the findings of the study.

Keywords: eLearning, teaching practices, higher education, digital competencies, openness, pre-pandemic

1 Introduction

The year 2020 defines what will probably be the biggest event of our century: the COVID-19 pandemic. The outbreak and health crisis that followed, overburdened health systems around the world, causing a unique excess of mortality, economic and social disruptions, as well as forcing a drastic change in education that led many institutions to remove themselves out of the classroom and adopt, instead, online teaching and learning strategies that were and still are carried out remotely, through digital platforms.

Even before COVID-19, in the field of education, information and communication technologies were already being used to improve pedagogical models and experiences, as well as introducing new foundations and solutions around further innovative pedagogies. There are many international higher education institutions that over the years have been transforming their teaching methodologies and practices by following constructivist paradigms, placing learning in virtual environments, focusing predominantly on students and, consequently, restructuring teachers' responsibilities seen as knowledge facilitators.

During the early stages of the pandemic outbreak some institutions across the globe were able to adapt easily to distance learning and teaching methodologies, implementing and adapting their technological resources to the new reality and involving the entire academic community (as well as governments) in the design of online teaching strategies capable of guaranteeing the continuation of learning (Morales et al., 2021); however, the sudden closure of face-to-face teaching and the adoption of asynchronous strategies has led, at the same time, many universities, teachers and students to an "unknown terrain" (Carolan et al., 2020). The generalization of the use of ICT, ambiguity of technological purposes, technological implementation and prerequisites in the higher education landscape describe, therefore, the most recent institutional realities of many countries.

Unlike the People's Republic of China or even its neighboring region, Hong Kong, until the end of 2019 Macau did not have a clear record of emerging innovative educational initiatives that combined the tradition of sharing ideas with the culture of the Internet, nor innovative and open educational practices in the teaching and learning processes at the level of higher education (Fengliang, 2018; Bandalaria, 2018).

At the beginning of 2020, the disruptions caused by the pandemic led the region of Macao to provisionally postpone classes at all levels during the Chinese New Year holidays, having only resumed, in stages, in March of the same year. However, due to the alarming increase of contagions in the mainland China, stricter border restrictions were imposed that prohibited the entrance of residents from China, Hong Kong and Taiwan. At the same time, the Chinese central government was imposing restrictions on inland travel due to the severity of the outbreak in several of its regions (Kohnke, Moorhouse, 2020).

Conversely, being Macau one of the higher education destinations for many Chinese students, a significant part of them were retained in their respective provinces, with no possibility of returning to Macao and in many situations with limited technological and connectivity resources at a time when the MSAR academic continuity was largely depended on the sudden development and implementation of online content. This unexpected change is presumed to have been difficult for local institutions as, until 2020, the digital skills of the teaching staff, the use and adoption of available technology for teaching and learning, as well as the lack of knowledge of institutional policies capable of implementing pedagogies at the level of eLearning, emerged as concerns that supported the problem of this study (which was carried out before the pandemic outbreak): *what are the trends in the use of open teaching practices in Higher Education in Macau?*

As there are considerable gaps in this field and it is confusing to understand what some institutions understand by open teaching or concepts such as eLearning, our study focused on unveiling the pedagogical dynamics and practices of eLearning in Macao higher education until the end of 2019 (Zawacki-Richter & Qayyum, 2019). We explored the patterns that emerge when teachers in the region integrate technologies in the teaching and learning processes, explaining the motivation and methods behind the adoption of these technologies in their teaching practices. The study also documents the characteristics of the institutions that include open teaching and learning practices in their organizational metabolism.

Based on the concepts already exposed, we developed a study that followed a quantitative approach, through a questionnaire, administered in two higher education institutions (one public and another private) of the MSAR. The questionnaire obtained answers from 106 local higher education teachers and focused on the intersection of four axes that combined the problem with the research objectives in order to outline a general depiction of eLearning practices in this region.

To characterize the digital profile of teachers, the first and second areas focus respectively on access to information and communication technologies for teaching purposes, and how this experience is applied in the classroom. In the subsequent area, we sought to find out what are the current trends in the use and the theoretical foundation of online teaching practices in these higher education institutions in order to better understand the individual reasons that lead to the consideration and adoption of certain technologies in the teaching-learning process. The last area, on the other hand, intends to deepen the convergence of the previous points by evaluating more specific data about the current functioning open practices. This helped verify the levels of awareness of the open movement, approaches and the theoretical and / or practical domain in the use of open educational resources in undertakings within the scope of eLearning.

2 Theoretical Framework

In recent years, distance education has evolved and several researchers as well as academics have been asserting the potential of eLearning for the ground-breaking transformation of education, pedagogical methodologies and learning experiences. In alignment with the evolution of pedagogical practices, there is a growing impetus among higher education institutions across the world to participate in the "open" movement, a reality that includes open pedagogies that facilitate learning processes and promote pedagogical quality through innovation in the academic configurations.

Distance education has been present in China since the middle of the 20th century and like many regions in the world, here too, distance education has been characterized by three “generations” (Anderson & Dron, 2011) that have been coexisting with each other until our modern times.

By contrast, in a first observation, there seems to be no pedagogical culture on online teaching and learning in the territory of Macao that resembles that of other more developed western countries or even in close comparison with central China or Hong Kong. In addition, the lack of literature and studies on emerging teaching practices in a location as specific as Macao makes it difficult to provide a reliable insight of the local pedagogical reality in this context.

Macao, a symbiotic meeting point between eastern and western culture, the latter marked by the presence of the Portuguese who colonized and administered the territory for more than 400 years since the 16th century, after Portugal’s handing over sovereignty to the People's Republic of China in 1999, a unique expansion in a short amount of years is obvious, not only its population, but also its economy grew instantly, in large part due to the expansion of casinos. However, Macao's handover also exposed some fragilities, namely the difficulty in developing a set of structural, solid and suitable elements for the socioeconomic development of the city. In a pedagogical sphere, the rapid regional development marked a quest for more educational opportunities, particularly in higher education. As the local society evolved and requested different professional skills and qualifications, the number of institutions and programs flourished as an integral part of the development of education, one of the priorities of Macao's governmental agenda until today.

It is, however, appropriate to note that the tertiary education system in this region only started to develop systematically in a more recent part of history. In general, and according to some authors, among which we point out, Koo & Ma (1994), Adamson & Li (1999) and Feng & Lai (1999), the pedagogical trajectory in Macau has been marked by traits of *laissez- faire*, with little government intervention until 1990.

According to the literature, even though the first learning centers were registered in 1572 with the presence of Jesuit missionaries in the old trading post of Macao by Portugal, after their expulsion, the intellectual and educational center that was established until then was destroyed, a historical event described by Yee (1990) as a disastrous turning point for Macao, where for two centuries found itself without any higher education institutions.

It was only in a more modern era that the first higher institution of Macau was created, in 1981, the University of East Asia, located on the island of Taipa. However, it did not serve the local population but, in contrast, attended to the educational needs of Hong Kong and other neighboring regions. In 1991, during the pre-transition to China, the Government of Macao acquired this institution and converted it into what has since been entitled the University of Macau (Yee, 1990).

The 1990s brought further development and diversification, as from this decade onwards, other higher education institutions were founded, four of which are public - the University of Macao, Macao Polytechnic Institute, Macao Institute for Tourism Studies and Macau Security Forces Higher School -, and six are private - Macau City University, S. Joseph University, Macao Kiang Wu Nursing Institute, Macao University of Science and Technology, Macau Management Institute and Macau Millennium Institute.

In addition to cultivating the educational offer, the importance of promoting professional quality was recognized very early on, an issue that has been difficult to resolve in Macao for a long time and has been evident even earlier, in 1984. In order to keep up with the region's social and historical advances, teacher training was introduced on a large scale and quickly became a responsibility, as well as an integral part of the government's discourse for the balanced development of the region, particularly in recent years.

Several initiatives were launched to optimize the higher education system and promote the quality of qualified institutions and professional frameworks, summarized by Sou-Kuan and Wong (2009) in two stages of development of teacher training: “The first stage, from 1982 to 2002, was an expansion period, particularly in relation to the number of teachers in training. In this stage, much emphasis was put on the target of producing qualified teachers through in-service qualification − upgrading programs and meeting the demands for more teachers as a result of population expansion. The second stage started from 2003 and, in this stage, the main focus was placed on the target of developing qualified teachers professionally through multiple channels of teacher development programs offered by the government and/or higher education institutions.” (Sou-Kuan & Wong, 2009, p. 36)

As for the incorporation of technologies in local pedagogical practices, this doesn’t seem to be a priority in said initiatives, this matter is rather unclear and inconsistent, leading to the ambiguity of terms such as distance learning, open learning, eLearning, as well as of the digital skills required for such practices and faculties awareness in this context, all aspects that we intend to demystify with this study,

Events like the COVID-19 pandemic can serve as an inflection point for pedagogical innovation, however, the rapid transition from pedagogical methodologies to the virtual world that has been witnessed all over the world and including in Macao, without any preparation, and in some institutional realities without complementary training in open and online pedagogical techniques or even without guaranteed technological conditions, raises some concerns as any form of online learning is only significant and effective when a relevant integration of ICT is established, but more importantly, when an understanding of the new demands of distance teaching and learning is fully attained. It is not enough to just replicate the physical class using audio-visual resources. In order to transfer learning to virtual environments it is indispensable to use a variety of collaborative and multidimensional tools that promote knowledge construction in a structuring way (Feijóo, Fernández, Arenal, Armuña, & Ramos, 2021).

In addition, the development of online education through emerging digital technologies also requires supplementary and specific characteristics from teachers. Not only are they expected to feel comfortable with interactive, inclusive, changing and progressive practices and strategies (Ally, 2019), they must as well obtain congruent and highly relevant digital skills to serve the society of the future (Major, 2010; Spector, 2007; Carril et al, 2013; Ally, 2019) and prepare students as holistic agents of the 21st century.

The lack of skills at the level of significant operationalization of emerging technologies in a pedagogical context, is a very current barrier. According to Roda and Morgado (2019), to the skills already acquired by the faculty, digital skills which are broader and multidimensional, must be added, which transcend the most basic knowledge of technologies and, ultimately, allow the recognition of teacher's limitations and abilities for a more structured and cognitive adaptation to the new teaching-learning process.

In Macao, the digital skills of the teaching staff for the systematic integration of ICT in the teaching and learning practices, in the light of the emerging pedagogies in higher education, is inconclusive, with no literature to support inferences.

3 Data and methods

Little to no research on digital and pedagogical strategies applied in higher education in Macao has been developed. This study addresses this gap to better assess and explore the local pedagogical reality in the context of alternative methodologies of teaching, such as eLearning.

The purpose of this study is to understand and analyze the pedagogical models and open educational practices currently used in two Macao higher education institutions in order to assist local institutions in structuring and optimizing their open teaching and learning practices. It also aims to enhance academic collaborative strategies, which have so far been insufficiently explored. For this reason, it was crucial to understand specifically which practices are applied in these said institutions by exploring the patterns that emerge in the use and integration of technologies for online education. Thus it would help to further explore the reason why certain technologies are adopted at the expense of others and how they are implemented.

Based on the concepts already exposed, we developed a study that followed a quantitative approach, through a questionnaire, administered in two higher education institutions (one public and another private) of the MSAR. The target population of this study are teachers from two higher education institutions in the Administrative Region of Macao. In total, 106 teachers respond to questionnaire over the Internet, anonymously and confidentially in Portuguese and English.

In order to safeguard the privacy of these institutions, as well as the confidentiality of the participants' responses, the respective university designations are not revealed.

Both institutions offer on-campus undergraduate and postgraduate courses. It is known that the two universities use different virtual learning environments and in terms of institutional structure and institutional culture with regard to the open educational movement, the respective policies or strategies are not known in neither institutional reality.

The questionnaire focused on the intersection of four sections that combine the problem with the research objectives:

Section A. Access to Information and Communication Technologies (ICT) in education

This is the first section of the questionnaire, with regard to the technological conditions that respondents have access to in their educational institutions. They were asked what kind of technologies and digital devices are given in their institutional environment and also how respondents evaluate the use of these devices in a learning context.

Section B - Experience with Information and Communication Technologies (ICT)

This particular section aims at understanding the experience of respondents in the use of technologies, in order to outline a digital profile of the teaching staff that could be completely authentic and comprehensive to the reality of the MSAR. As such, it was extremely relevant to ascertain whether technological training is mandatory in both of these institutions, while questioning the frequency and digital comfortability in which these respondents have been handling certain technological tools and resources, through a general framework.

Section C - eLearning / online Practices

In this part of the questionnaire, general knowledge about eLearning, the current trends in the use and foundation of online teaching practices, and what are the perspectives, notions of relevance and individual reasons that lead to weighting and / or adopting certain practices in the classroom, were observed. In addition, some of the questions focused on obtaining specific data related to the institutional encouragement of pedagogical practices oriented towards online teaching and eLearning. Notions of barriers and benefits were sought in the outcome of this section, which will reflect the participants' position in relation to online teaching and learning practices.

Section D - Open Educational Resources - use, publication and attitudes

Part of the questions in this section was adapted from the Cardoso Questionnaire (2017) and Cardoso, Morgado and Teixeira (2019). In this last section, the objective was to deepen the convergence of the previous points and to evaluate more specific data about the current open procedures in practice in the MSAR, focusing on the theoretical and / or practical domain in the use of open educational resources in eLearning activities. Some questions included in this final part of the questionnaire were also intended to verify the levels of awareness of the open movement.

The closure of the questionnaire enquiries the frequency of collaborative work between teachers and higher education institutions in Macao, since collaborative work is intrinsic and essential to the sustainable development of online teaching methodologies.

4 Results and Discussion

(i) Teachers favour the use of technology in the classroom and consider it to be very appropriate for students' learning.

A careful analysis of the results obtained revealed that the use of technologies by the teaching staff of these institutions permeates their pedagogical practices. The teachers covered in the study show that they have easy access to technologies in their educational institutions, pointing out, firstly, the desktop computer with Internet access (99%), followed by the laptop, tablet or notebook with Internet access (81%) and, thirdly, computer laboratories (80%).

However, it should be noted that only 68% of respondents have access to computers with a built-in webcam and only 39% to other imaging devices such as video cameras. This demonstrates a possible obstacle to the pedagogical practices supported in virtual classrooms by videoconference and may therefore be less plausible due to their low accessibility; as well as other activities that characterize online teaching and which require audio-visual resources to complement and improve the learning experiences, such as synchronous meetings between teachers and students.

A great number of teachers (66%) also reveal that they use technology frequently in their classes and evaluate it as a very important component for the good performance of their lectures, recognizing that the use of digital devices is a very appropriate component for students learning: according to 62% of the respondents, the students' involvement in the teaching / learning process is beyond palpable when some form of technology is used. However, with regard to the use of eLearning in the classroom, it appears that a significant majority of the teaching staff (82%) never taught an online course, which shows that the informant’s pedagogical experience is enhanced mainly by face-to-face classes. The data suggests that teachers integrate technologies for teaching (e-Teaching), but in a restrained approach, combining only these tools with the traditional models of education which characterizes the studied institutions, as well as the learning culture in Macao overall as stated in the theoretical framework.

Having established that, it is evident that distance education and eLearning until 2019 were not evident in the methodologies and pedagogical practices of higher education in these two higher education institutions.

(ii) Complete access to technologies in higher education institutions while weaknesses in specific digital tools / resources are shown due to the lack of training.

In this study, the majority of teachers reveal that they use technologies such as computers for a long time, although their technological skills are not adequately developed as it will be described subsequently.

The highest rate of experience in handling computers situates in the range of 20 years, representing 25% of the respondents (table 1).

Table 1.

Question 1: How long have you been using computers? Refer the number of years.	
20 years	**25.47%**
30 years	**17.92%**
25 years	**16.03%**
Total	**59.42%**

There is some comfort and technical aptitude in the use of these electronic devices. However, in order to comprehensively understand the levels of digital literacy that go beyond the use of computers and to obtain an authentic digital profile of the teaching staff, some tools, software and other digital / online instruments that are regularly incorporated in eLearning pedagogical practices and distance education were considered (table 2).

Table 2.

Question 2: **Please indicate the level of use frequency for each of the following?** ***Question 3:*** **How would you rate your skills in using each of the following?**		**Freq. Q.2**	**Comp. Q.3**
1	Microsoft Programs (Word, Power Point, entre outros)	**4.73**	**4.33**
2	Email	**4.77**	**4.49**
3	Internet	**4.82**	**4.34**
4	Learning Software (CD-ROM, DVD)	**3.17**	**3.66**
5	Blog	**2.64**	**2.80**
6	Wiki	**2.83**	**3**
7	Podcasts	**2.44**	**2.60**
8	Social Media	**3.35**	**3.42**
9	Video conference	**2.44**	**3.02**
10	File sharing sites	**3.22**	**2.88**
11	Computer Games	**2**	**2.31**
12	Learning Platform (e.g. Moodle, Canvas, or others)	**3.22**	**3.18**

Scale (Question 2) 1. Never 2.Rarely 3.Ocasionally 4.Frequently 5.Always
Scale (Question 3) 1.Very weak 2.Weak 3.Aceptable 4.Good 5.Very Good

These resources were organized according to levels of frequency and assessment of competencies, and the data was split up in order to organize secondary tables, specifically considering online resources and digital tools that are more or less frequent and corresponding aptitudes that are more or less classified.

Observing the five most frequent digital resources / tools, it was possible to verify that the respondents show some dexterity and comfort in the use of especially uncomplicated digital programs / tools for information and communication processing which are easier to use and as such the digital tools that provide more self-assurance due to their familiarity. On the other hand, this data also attests that the teachers' insecurity combined with insufficient individual competencies in the application / implementation of other more complex tools, justifies the anemic use of these digital resources.

The lowest frequency index falls under tools / resources of complex nature that require transversal skills such as the creation of digital content, communication, collaboration which the faculty, in its generality, classifies in proficiency as “Weak” and “Acceptable” (table3).

Table 3.

	Five online resources and digital tools with the LOWEST competency rating index	**Freq.**	**Comp.**
11	Computer Games	**2**	**2.31**
7	Podcasts	**2.44**	**2.60**
5	Blog	**2.64**	**2.80**
10	File sharing sites	**3.22**	**2.88**
6	Wiki	**2.83**	**3**

In a day and age when the evolution of digital technologies has already shaped social interactions and, more importantly institutional dynamics, the digital skills required for educational environments have long since distanced themselves from the use of computers or word processing software; other transversal solutions and competencies are needed, ones that include collaboration, sharing, editing and content creation, since the insertion of technology in education is inevitable (Redecker and Punie, 2017; Inamorato dos Santos, 2019). However, in order to know how to use technology in a pedagogical context and for teachers to be able to follow this digital evolution, it is also essential that support and training conditions are created, complementary to their functions. A vast majority of the informants, state that in their institution these circumstances are not provided (Fig. 1). Therefore, the mastery of several digital skills, particularly assessed by these teachers as the weakest and underdeveloped, has no support which subsequently will be harder to understand and apply in the teaching/learning context.

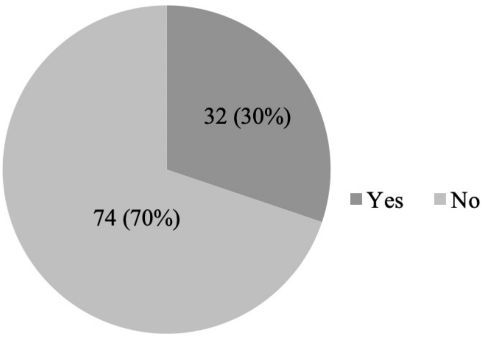

Fig.1. Compulsory Teaching Training in ICT

(iii) Teachers are hesitant about their participation in online pedagogies

In addition to expressing clear difficulties in the use of certain digital tools, there is a very significant inexperience in the administration of online courses since 82% of the participants recognize that they have never taught an online course, and there is no strong will evidence in participating in these pedagogical practices in their future career either (Table 4).

Table 4.

Question 5: **In the future, do you plan to teach or continue to teach an online course?**	
Yes	**25.47%**
No	**20.75%**
Maybe	**53.77%**

However, the teachers were unanimous in stating that there are benefits and considerable relevance in all pedagogical practices that are developed through the network, referring aspects such as “active learning” that online courses provide, “flexibility” and “asynchronous accessibility”, the opportunity for “autonomy”, the “increased interactivity and engagement of students”, the creation of “personalized learning rhythms” and “greater freedom in the management of personal learning and academic work” as positive characteristics that mark online teaching and learning experiences.

Having teaching practices only assisted by technologies (as the results previously suggest), the conceptualization of other pedagogical initiatives is restricted, such as eLearning, b-Learning, among other ramifications of online teaching. These factors might be very well responsible for the apathetic way in which teachers view online teaching, leading to their demotivation and disconnection from the open movement.

(iv) Encouragement and development of online teaching practices by institutions is ambiguous

The encouragement and development of pedagogical practices that are focused on online teaching by both universities is also not transparent, leading to the ambiguity of the methodologies and practices developed internally. All teachers characterize their pedagogical functions until 2019 as being face-to-face, thus attesting that until this date there was *no offer of eLearning or b-Learning courses* being developed or implemented by these universities. However, technology and the complementation of activities and practices through technology do occur in the MSAR, in a perspective that suggests technology integration in teaching and learning as an accessory component or peripheral educational practice.

When asked about the *development and encouragement of online pedagogical practices*, at an institutional level, 46% of the participants say they are not aware of whether this type of initiative is currently being developed in the institutions they work for, which suggests a significant lack of knowledge about the institutional efforts to raise awareness about the open educational movement and new pedagogies.

In turn, this may mean that the institutions do not consider to be relevant the development of this type of emerging practices.

(v) Guarded positions considering the use and publication of open educational resources

The technological use in the educational landscape of Macao is still very limited; This study shows that not only eLearning practices are not adopted, but confidence in the use or publication of open educational resources, for example, is not demonstrated. A subtle majority of teachers (52%) know the concept of OER, however, for almost half of the respondents, this definition is still unfamiliar (these results are similar to those obtained by Cardoso, Morgado and Teixeira, 2019). The data also indicates that the participants mostly use educational practices that are dependent on printing, where the vast number of learning resources take the form of traditional textbooks (table 5) which, in addition to being expensive, are exposed to a greater possibility of being outdated, exposed to contextual irrelevance, besides the fact that its distribution among learners is more complicated (Keats, 2003; Lwoga, 2012).

Table 5.

Question 6: **What kind of materials are mostly used in your classes?**		
1	Originals	**19.81%**
2	Textbooks	**45.28%**
3	Materials from other academics, adapted by the teacher	**30.18%**
4	Others	**4.71%**

About 58% of the informants say they have *never used OER from other academics*, while 16% *do not remember*. The underlying inhibiting factors that prevent these individuals from using or publishing OER in the development of their pedagogical practices are significantly manifested in the expectations of publication, since 55.5% of the participants assume as a major concern the *possible negative impact that the publication of their materials could imply in their academic reputation*, followed by 53.7% who consider *copyright infringement to be a significant barrier*, as well as 50% of respondents who point out the *lack of reward / recognition* as another reservation.

Other limiting factors are pointed out, such as the *lack of knowledge about open repositories* (48.1%), *lack of user feedback* (45.2%), *criticism from colleagues* (40.56%) and, finally, *criticism from students* (32%).

(vi) Collaborative practices among higher education teachers is not a common feature in the MSAR

Collaborative work is one of the key elements of new generations of distance education models that allows diligent activity in the construction of knowledge, which, therefore, contributes to the improvement of students' learning, making them proactive and the main agents in the construction of knowledge.

Just as collaboration is essential for the promotion and acquisition of holistic and meaningful learning, it also permeates the entire eLearning structure, extending “from planning and development to the evaluation and ongoing support of online programs” (Vandenhouten, 2014, p. 3)

In order to maximize the quality of online programs, academic professionals must therefore communicate, interact and share ideas to outline strategies and cover all aspects of eLearning (Khan, 2005).

In a global assessment of pedagogical collaboration in the academic repertoire of open educational practices in Macau, this study shows that according to the teachers’ responses, collaborative work in Macao, both among teachers and between institutions, only occurs “Sometimes”.

In the presence of a hybrid society like the one that characterizes the 21st century, it is urgent to contemplate strategies that contribute positively to the articulation of the learning, teaching and digital technologies processes, while creating transformative foundations for the being and the creation in contemporary pedagogy and for the new challenges of the present and future.

Thus, the expansion and formation of collaborative links between local institutions and educators as a multi-component of innovative pedagogies and, above all, as a political strategy to improve the performance and professional quality of higher education, although complex, has never been more necessary.

Johnson (2012) argues that collaborating can “strengthen the institution by connecting people, sharing knowledge and opportunities, increasing internal competencies, leveraging specialization and identifying effective needs and solutions”, but more importantly, collaboration instigates alternative, broadly holistic points of view, which the more traditional institutional panoramas cannot.

5 Conclusion

Having collected the data from the participants, we present the following considerations and final recommendations.

Despite the represented institutions having technological conditions at the disposal of their academic community, most of the teaching staff manifest significant weaknesses in the use of more complex digital tools, conditioning their continuous use, with only fluency in skills that are aligned with the application of programs and digital tools that are especially simple and require a basic domain, such as information and communication processing tools; this conclusion allows us to answer two fundamental questions that have leveraged the study: *What technologies are being used in the context of higher education teaching / learning by its teachers?* and moreover, *What is the teacher’s “digital profile”?*

As for the reasons that lead the teaching staff to adopt certain technologies in their pedagogical practices, other question in this investigation, it was not possible to obtain a truly explicit clarification, and it can only be inferred that there is a strong correlation between *digital comfort - handling of complex digital tools - assiduous application*.

Taking these results into account, it seems essential that support and training opportunities are developed so that teachers are equipped with relevant, appropriate and absolutely integrated digital practices in the context in which they are inserted - pedagogically. The new learning paradigms cannot be characterized, only and erroneously, by the use of Internet in classes. In addition to the misunderstanding of concepts and standards in the redefinition of pedagogies, with regard to the incorporation of technologies in teaching practices, it is also necessary to ensure that teachers are digitally fluent, but firstly, knowledgeable (Inamorato Santos, 2019).

In addition, the renewal of existing pedagogical models and the integration of ICT in the institutional curriculum (and not only in pedagogical practices) is inevitable in order to overcome these challenges and allow the germination of differentiated learning guided by new dimensions of knowledge acquisition. In order to achieve this, teachers will also have to learn how to share and build knowledge.

As there is a possible teacher's discomfort in the use of certain collaborative and multidimensional digital technologies and tools typically used in online learning and teaching environments, in addition to specialized complementary training in transversal digital skills, open dialogues should be created among the academic communities of the MSAR in order to gather richer perspectives that will contribute, consequently, for the assessment of the adequacy of emerging pedagogies in specific training contexts.

It is recognized that the collaborative discussion of these precepts is important in affirming and changing the pedagogical dynamics, as frequent collaboration can allow the specialization of areas of indispensable strength, allow the combination of distinct and complementary skills for the professional guidance of teachers (Boggs and Trick, 2009; RMIT University, 2017; Williams, 2017), the standardization of concepts such as "openness", "eLearning", "b-Learning", among others, as well as it can facilitate the contact with other teaching and learning experiences, encouraging in this process the design of balanced pedagogical procedures that assure the development of the educational system in particular of higher education.

The institutional intentions regarding the development and support of learning and pedagogical practices supported by technology must also be clear, as the study shows an extremely ambiguous predisposition in this sphere.

In the study, the following question was asked: *What is the impact on students when adopting eLearning practices in higher education?* To this question, the questionnaire was unable to obtain a tangible answer, since there is no evidence of an in-depth record of eLearning practices in the MSAR (in a first assessment, only evidence of e-Teaching).

Consequently, the question *What are the teachers' eLearning practices?* It is manifested as unfavorable, since the informants' professional experiences are found to be enhanced mainly by face-to-face teaching, with no evidence of online and distance learning modalities, which means that the technology used in higher education in Macao refers to the support of pedagogical practices and learning experiences, but are not necessarily expanded beyond the classroom.

Although there are technological conditions at the disposal of the teaching staff, the theoretical recognition of technological potential or the valorization of online learning, *per se*, is also unsatisfactory.

It is imperative that both institutions and professionals understand that the presence of technology as a component that improves the pedagogical quality is not enough; it's necessary to expand and nurture teaching and learning experiences, whether one opts for eLearning, b-Learning, or other online-assisted. The implementation of broader and more dynamic learning experiences that involve the construction of diligent and innovative knowledge, where learning is positioned on the student, at the same time that active roles are assigned in the collaboration and construction of that knowledge, and more proactive, transformative and highly relevant teaching skills are developed, has never been more relevant in Macao.

The last decade has been marked by a myriad of advances, discoveries and technological transformations that have contributed to the expansion of the traditional frontiers of education and shaped the society of learners who are now looking for highly personalized teaching experiences based on transversal, higher-order skills, "multifocal and multivocal" (Santanella, 2010, p. 304), more and more indispensable for the job market.

But without a doubt, the biggest event in recent years that changed the world and societies, was the pandemic COVID-19. Since 2020, all everyday activities have changed dramatically in an attempt to prevent the spread of the virus and fight the outbreak. Universities and schools around the world were forced to close their doors, using distance learning to continue teaching and respond to the new reality.

However, this sudden change has forced both teachers, students and the institutions themselves to use a variety of unknown teaching methods in a schizophrenic adaptation and with potentially damaging future impacts. Recent studies reveal that colossal difficulties in distance learning have been felt all over the world, mainly due to inexperience in online teaching, which, consequently, has been affecting the quality of teaching and learning experiences (Cicha et al, 2021).

In Macao, although there is no literature yet on the impact of the pandemic outbreak on local education, particularly on higher education and the academic community in general, it is known that the difficulties described above were observed at the two universities enclosed in this study. The lack of clear information on how to incorporate open tools and methodologies, the complexity of the new learning environments, the clear evidence of insufficient digital skills in most of the teaching staff, discrepancies in students technological access, the constant concern and focus in students' mental health during the peak of the outbreak in mainland China, as well as the enormous institutional challenge in re-directing teaching processes without guidelines or previous local reference models that could efficiently direct online education, are some other strangling obstacles that marked the second semester of the academic year of 2019/2020 for these institutions.

The problems that were felt during this phase were identified beforehand in this study as barriers in the adoption of innovative pedagogies. And because it is still unknown how long the pandemic will last, as well as the new reality in which we live now, it becomes even more relevant to reflect, but above all to adopt and anchor new strategies in current higher education that promote meaningful and fully holistic pedagogical practices capable of safeguarding the modern needs of learners, as well as supporting teachers and educational institutions in Macao.

The creation of an adequate systematic support that includes supporting guidelines that directly address these complexities is an arduous task, since the transition from classroom to virtual is not just a spatial issue. Thus, it is advisable to outline a set of principles that extend from the internalization of new specific pedagogical functions in a networked classroom, as well as the characteristics of the learners who resort to this type of teaching. In addition, these new pedagogical functions must also be unfolded in the remodeling of the inter-action dynamics between teacher-student-institution, in the establishment of metrics that ensure the pedagogical quality and the multidisciplinary online learning experiences, in the construction and management of sophisticated technological infrastructures, in the reconceptualization of pedagogical practices and in the adequacy of institutional policies (Ragan & Schroeder, 2014).

Likewise, special attention should be paid to the revision and modernization of the region's curricula, requiring the MSAR Government to participate actively, since this task is not a purely an institutional responsibility.

The study described here hopes to complement the literature, contribute to the creation of a pedagogical culture more focused on the concept of 'openness' and offer opportunities for future and collaborative research, both in the Macao Special Administrative Region and elsewhere.

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Hidden under the Fog of Remote Teaching with Zoom: At-risk Student Detection in a Pandemic-impacted Course

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Abstract

Purpose – Early detection of academically at-risk students is critical for retention. Remedial measures for these students can be administered in time to bolster the chance of their passing a course. Building a reliable model for identifying at-risk students is both desirable and challenging. A selection of predictive and observable model variables is required. Predictive variables contribute to model accuracy, and practically the variables must come from observable footprints of students left behind during their interactions with a course. As the set of observable footprints and their predictive power can change from one educational context to another, a universal model for at-risk student identification cannot exist. To seek predictive model variables in a new situation, scientific evaluation of the observable footprints is necessary for model building. The social lockdown induced by the COVID pandemic has drastically altered the educational context in higher education. The replacement of face-to-face teaching with Zoom teaching is an emergency arrangement that has clouded the status of students. For example, students' attention level in classes is not observable due to poor video resolution or switched-off cameras. Fortunately, Zoom makes available several digitized footprints of learning activities that are potential model variables for detection of at-risk students. The aim of this research study is to evaluate the effectiveness of these footprints for the prediction of the academic performance of students in a computing course during the spring 2021 semester.

Design and Methodology – The Zoom footprints evaluated include attendance and polling records of students. The polling was designed as a formative quiz with questions about the materials covered previously. Each Zoom session had one to two formative quizzes. The downloaded footprints and their derivatives were used as input model variables for the prediction of their summative assessment results with a supervised machine learning algorithm. The effectiveness of a variable was measured by Mean Decrease Accuracy, which is defined as the decrease in prediction accuracy after the removal of the variable. The feasibility of early detection of at-risk students was also evaluated by comparing a sequence of models built from footprints of shorter time spans.

Findings – The most effective variables for predicting at-risk students found in experiments were related to summative assessment. When summative assessment was not available, formative assessment could make significant contribution. The variables related to attendance were irrelevant. The prediction accuracy of the best models reached over 0.80 based on fivefold cross- validation.

Value and Implications – Accurate detection of at-risk students is inherently challenging in courses affected by the pandemic, because many relevant factors become hidden in online teaching. This study showed that regular formative quizzes could offer the footprints effective for the detection of these students. The findings have added to the body of knowledge in understanding the predicting of the academic performance of students in Zoom teaching.

Keywords: COVID pandemic, Zoom teaching, at-risk student prediction, learning analytics, machine learning

1 Introduction

Tracking the academic wellbeing of students is essential for informing teaching and learning. Interactions between students and their courses leave various footprints that may be collected, analysed, and utilized for the improvement of course delivery. Short-term prediction of academic performance involves making observations on the activities of students within a course and then evaluations of their success rate at the end. One critical benefit is the enabling of rapid deployment of appropriate interventions for students who are at risk of fail the course. The duration of typical university courses lasts an academic term or around a dozen of weeks. The challenge is to make predictions earlier in the course or to be caught out with inadequate time for any meaningful rectification. The prediction must exploit potential factors that are available early, and supplement with possibly more reliable factors later. The former factors include various essential and additional learning activities starting from the first weeks. For example, many experienced professors can model the wellbeing of the class from observations of in-class participation, and to siphon more information through the engagement in formative assessment and online activities. Summative assessment, of which the schedule is often beyond mid-course, may then offer increasingly accurate predictions and improvements of the wellbeing model.

The need for social-distancing induced by the COVID-19 pandemic has drastically changed teaching and learning. Moving in-person face-to-face classes to online platforms is practiced as an emergency arrangement in many universities around the world. Zoom is a popular video-conferencing and synchronous teaching platform that has overcome the distance between teachers and students. There remains significant difference from in-person face-to-face classes. As students can interact with their teachers through a range of functionalities, they can also set up communication barriers with the same ease. Students may choose to manipulate the video quality, engage in something else off camera, or simply switch off the camera. The reasons may well be acceptable, perhaps unrelated to their academic engagement, and always a mystery to the teachers. Remote teaching in a thick fog is a shared lamentable experience. A reliable method for tracking the progress of students on the other side of the barrier is needed.

The capacity of automated user action tracking is an attractive feature of technology-supported remote teaching. The Zoom platform is no exception. The student activities recorded include the time of joining and leaving a session, the total duration, and discussion transcripts. Additional information can be elicited from students through adapting the online polling function for formative assessment and in-class feedback. If the academic wellbeing of students is embedded in these activities, then there is a wealth of relevant digital footprints available on the Zoom platform. There is enough data for early prediction of academic performance even in the first few weeks of a course.

This paper describes a feasibility study on short-term prediction of academic performance in a Zoom-supported course. A reliable prediction model requires strong predictive independent variables. The study investigated the predictive power of various digital footprints collected in the Zoom platform, including native and customized footprints. It also addressed practical issues such as whether the predictive power of a variable changes with time and the reliability of prediction model in the earlier part of the course. The study employed a machine learning approach for the evaluation of the usefulness of various variables and models. Utilizing machine learning in data mining tasks has been found to be effective in many domains including education.

The remainder of this paper is structured as follows. The next section reviews the relevant literature in data-driven academic performance prediction and at-risk student identification. In particular, the past findings of predictive variables for academic performance in both conventional face-to-face teaching and online teaching are outlined and the existing methods for building prediction models are described. The machine learning approach will be highlighted. The research questions and the method employed for answering them are described in the methodology section. The findings related to the research questions are then provided in the result section. The paper ends with an evidence-based conclusion and a suggestion of future research direction.

2 Literature Review

The detection of at-risk students is an area of interest in the general field of academic performance prediction in learning analytics (Wong, 2017). A primary objective is to facilitate better student retention through informed remedial actions (Laskey and Hetzel, 2011). The desire of retaining more students has driven various implementations in universities around the world. A programme level prediction uses students' history, including pre-admission grades, to evaluate the chance of dropout and graduation (Star and Collette, 2010). A course level prediction is comparatively shorter-term that makes predictions on the eventual performance of a course. It is also comparatively more significant on the course grades as suitable interventions may be administered during the course. As a course typically lasts just a dozen of weeks, a practical course level prediction should start early in the course so that there is adequate time for intervention (Russell et al., 2020).

2.1 Course Performance Prediction Models

Building a course level prediction model must address three major technical issues, namely the form of performance prediction, the predictive variables, and the modelling techniques. The common forms of predictions include numerical regression and logistic regression. The former can predict numeric scores and the latter can predict binary or multiple performance classifications such as at-risk and grades. There are mature modelling techniques for making these forms of prediction. Recent work in student performance prediction mainly applied computational techniques including conventional and deep artificial neural networks, variants of decision trees, support vector machines, logistic regression classifiers and others (Hu and Rangwala, 2019; Olive et al., 2019; Cui et al., 2020; Márquez-Vera et al., 2016). These techniques are data-driven, meaning that the prediction models are learned from data. Noisiness, biased distribution, and small sample size are undesirable characteristics of data that can hinder model learning. The predictive variables are the input to the model but not all variables associated with students in a course are predictive. Any correlation between students' performance and predictive variables is highly contextual (Gašević et al., 2016). In addition, a predictive variable may become missing in another context or another platform. For example, the Zoom platform and other Learning Management Systems (LMS) provide different learning contexts and make available different variables.

2.2 Predictive Variables and their Availability

The literature in learning analytics and at-risk student detection has studied different variables for performance prediction. Continuous summative assessment has good predictive power simply because it is part of the final grade. Such variables are present in almost all courses, and therefore usually selected for learning the prediction models. Formative assessment can appear in various forms that may directly measure academic performance or latent variables associated with study skill, attitude, and other non-cognitive factors (Krasne et al., 2006). Formative assessment can provide predictive variables if it measures knowledge related to the intended learning outcomes (Ekolu, 2016). A superior characteristic of formative assessment is flexible scheduling, because it is equally suitable for during-learning and after-learning evaluation. It can be administered early in the course, unlike summative assessment that is only suitable for after-learning evaluation.

Learning analytics thrives on rich data sources. Online learning platforms offer an ideal environment for gathering data derived from learning and other activities. Many actions such as logins, clicks, views, and downloads have been explored in research studies, founding on the premise that these variables have a collective interpretation of educational significance (e.g., Chen et al., 2020; Cui et al., 2020). As the richness of variables can generally boost accuracy, there has been a trend to engineer more variables for model learning. One approach is to utilize disposition variables (Russell et al., 2020; Chen et al., 2020). Another approach is to create more opportunities of user tracking with an enhanced learning platform. The reported accuracy of these specialized models were good, and the design may be adopted in other courses with the same context. In practice, however, the performance of these models suffer if there is any deviation in the course design and platform functionality. The highly specific engineered variables make these models poorly transferrable to other contexts (Gašević et al., 2016).

A portable prediction model design can perform in a range of educational contexts. Online learning platforms can potentially offer many tracking variables but sometimes in practice few variables are available for use. It may be due to institutional policies, authorized access, and other ethical considerations. Recent work has shown that machine learning models were able to partially compensate the limitations with the variables. Olive et al. (2020) proposed a one-size-fit-all model for at-risk student identification. The model was designed for online platform portability through exploiting the commonly available variables. Wakelam et al. (2020) demonstrated a feasible at-risk prediction model that could work with small sample as well as small variable sets.

Face-to-face teaching is an educational context poses challenges in building prediction models. Past research has found some useful variables such as participation (Choi et al., 2018), note-taking (Manzi et al., 2017) and eye-gaze (Zhang et al., 2020). However, digital tracking of these activities in conventional classrooms depends on specialized technologies. At present, only attendance taking systems and student response systems may be regarded as commonplace. Other high-end tracking devices still remain in experimental stage for the foreseeable future.

2.3 Research Questions

The Zoom platform has taken up the baton to provide synchronous face-to-face teaching during the COVID-19 pandemic. The major student activities include attending synchronous video classes and reviewing video recordings. In addition, students can chat with written text and participate in online polling. The latter can be adapted as formative assessment. The platform provides these student tracking data to teachers for analysis. Note that such tracking data is often not available in conventional classroom teaching.

Many teachers are lamenting that Zoom teaching is like walking in a thick fog. Using in-class visual observation to mentally model the status of students is no longer feasible. On the other hand, the tracking functions in Zoom offers a new opportunity of building data-driven academic performance prediction models. The main research question is whether it is feasible to build such models for early detection of at-risk students based on Zoom's tracking data. For simplification, the main question is divided into the following components to be addressed in this study:

- The design of machine learning based models suitable for Zoom tracking data.
- The contribution of engineered variables towards prediction accuracy.
- The performance of the models built from tracking data at various points of time in a term course, from the first weeks to the last weeks.
- The performance of the models with respect to different scheduling of formative and summative assessment.

3 Method

To answer the research questions, a series of prediction models were designed, built, and evaluated using retrospective data. A Zoom-based course of 13 weeks and 240 students was selected for the study. The course was presented in the Spring 2011 term and its taught about computer operating systems. There were 2-hour online lecture session every week, and formative assessment was developed and scheduled in every session since the second week. The summative assessment has four continuous components scheduled during the online lectures and a final component at the end of the course. The Zoom platform provides the following raw tracking data from which a set of variables were engineered.

- The start time, end time, and the duration of every session.
- The join time, the leave time and the stay time of a student for each session.
- The answers and submission time of every poll question of a student.

Every model was built from a selected subset of the variables as input against the target output of a component of summative assessment. In some models one or more of the continuous summative assessment was included in the input variables.

Figure 1 depicts the method with a graphical illustration of the procedure and the data flow.

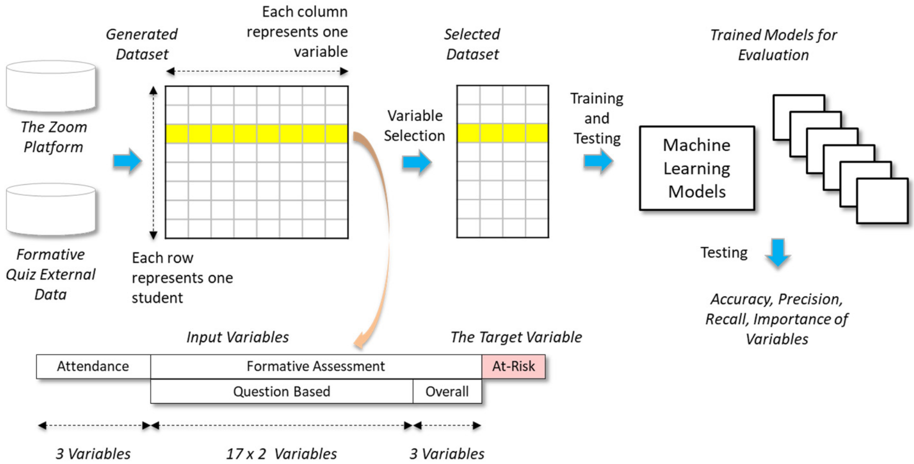

Fig. 1. The method design for this study. The procedure of data collection, dataset generation, variable selection for different models, training machine learning models with selected dataset and evaluation is shown above. The structure of the dataset is also illustrated, in particular the composition of the input variables representing every student in the course.

3.1 Machine Learning Models

The prediction models were built based on supervised machine learning. A supervised machine learning model enables the learning of a function that uses a set of input variables to predict a target variable. The machine learning model includes an effective algorithm that can learn the function from training data. The training data provides mappings between input variables and the target variable derived from real cases.

This study utilized the following machine learning models, which are commonly used in learning analytics studies.

- Logistic Regression (LR). LR models a binary target variable by learning the parameters of a logistic model that maps a linear combinations of input variables to a probability output.
- Decision Tree (DT). DT models a partitioning of data according to the target variable by learning a set of rules.
- Random Forest (RF). RF is an ensemble of decision trees each of which is built using a subset of training data. The predictions of the decision trees are aggregated as the final prediction.
- Artificial Neural Networks (ANN). Multi-Level Perceptron (MLP) is a common class of ANN, which contains a set of interconnecting nodes that loosely simulate the neurons of a biological brain. It models a target variable by learning the weights between the nodes through which the input variables are mapped non-linearly to a probability output.

3.2 The Target At-risk Student Model

As the target variable, at-risk students represent those expecting poor academic performance. The study considered two models of at-risk students.

- Absolute at-risk scale. Students obtaining a final assessment score that is below a certain passing threshold.
- Relative at-risk scale. Students obtaining a final assessment score that ranks below a certain percentile.

Both are practical models for various educational applications. The study compared the prediction model accuracy according to the choice of the at-risk student models.

3.3 Formative Assessment Model

Formative assessment contributed a significant number of input variables for the academic performance modelling in the study. Each assessment event, consisting of 3 questions, was scheduled either before or during an online lecture session. The pre-lecture assessment focused on the topics of previous lecture and the in-lecture assessment tested the content in the current lecture. There were 17 formative assessment events scheduled between Week 2 to Week 13 of the course. Figure 2 illustrates the scheduling in detail.

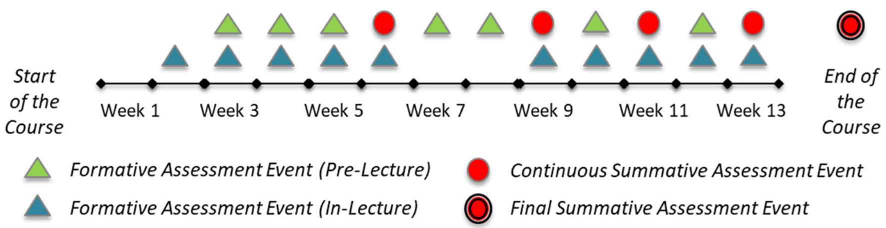

Fig. 2. The scheduling of the formative assessment events and the summative assessment events in the lecture sessions in the 13-week long course.

Each of the total 51 questions contributed to the following variables.

- Participation of a student (binary encoding).
- Correctness of the answer of a student (binary encoding).

The following lists variables concerning the overall participation of a student. The latter intended to measure the motivation to finish the assessment event.

- The proportion of questions attempted.
- The proportion of questions answered correctly.
- The proportion of assessment events attempted early (i.e., before a certain time lapse threshold).

3.4 Input Variables for Model Learning

The full set of input variables consisted of the ones engineered from the formative assessment and the ones derived from Zoom attendance records. No disposition variable was included.

The variables derived from Zoom attendance records of a student included the following. These were used to measure the motivation of joining the lecture sessions.

- The proportion of lectures attended.
- The proportion of total duration of lectures present.
- The proportion of lectures joined earlier than the scheduled start time.

The study involved evaluation of a series of models representing the problem of making predictions at different points of time. The variables associated with each formative assessment question was tagged with the time since the course started. The variables of overall assessment event participation were also functions of the time of making a prediction.

3.5 Model Designs for Evaluation

The study evaluated several models that represent common scenarios in the use of short-term prediction of at-risk students in a course. The following lists the scenarios that were explored.

- Early prediction used the activities in the first few weeks to predict the first continuous summative assessment or the final assessment.
- Mid-way prediction used the activities in the first half of the course to predict the final assessment. There should be adequate time for remedial actions to take effect.
- Late prediction used all activities in the course to predict the final assessment.
- Rolling prediction made weekly predictions of the coming summative assessment based on past activities, including both formative and summative assessment events.

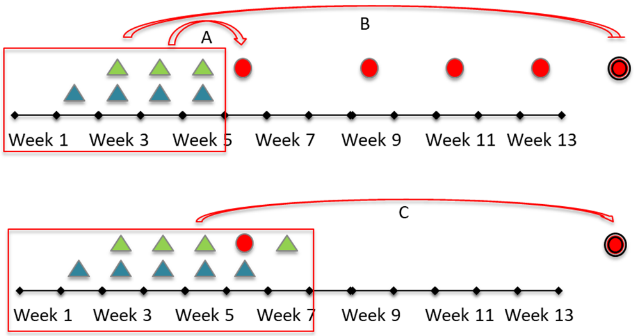

Fig. 3. Two examples of short-term at-risk student prediction scenarios. The top displays an early prediction of the coming continuous summative assessment (A) and the final summative assessment (B). The bottom shows a mid-way prediction (C) that should allow adequate time for remedial actions.

3.6 Evaluation Metrics

A good prediction model should make accurate predictions and more. The following lists the metrics used to gauge the quality of the models.

- Accuracy. The proportion of correct identification of at-risk students.
- Precision. The proportion of ground-truth at-risk students among the predicted set of at-risk students.
- Recall. The proportion of predicted at-risk students among the ground-truth set of at-risk students.
- F1 score. It is the harmonic mean of precision and recall, which is a more balanced measure.

The data sample was split into training and testing datasets. To alleviate random bias, five-fold cross-validation was used to evaluate the models, meaning that after splitting the data sample into five parts, each of which took turn to be the testing dataset and the rest was the training dataset.

Some input variables are more predictive than others. The Mean Decrease Accuracy (MDA) of a variable measures the decrease in prediction accuracy after the removal of a variable. The greater is the extent of the decrease, the more important is the variable.

4 Results

Several Python programs were developed as the experimental platform. The machine learning models were implemented based on the third-party modules *sklearn*, *pandas*, and *numpy*.

4.1 Performance of Machine Learning Models

The four machine learning models, namely LR, DT, RF, and ANN, were evaluated based on three scenarios, which included late prediction (end of week 13), mid-way prediction (end of week 7), and early prediction (end of week 5). The prediction target was the at-risk students in the final summative assessment occurred one week after the end of the course. Table 1 summaries the findings.

Table 1. Performance of the four machine learning models in the scenarios that predicts the at-risk students in the final summative assessment.

		LR	**DT**	**RF**	**ANN**
Late Prediction	Accuracy	0.701	0.705	0.812	0.704
	Precision	0.699	0.736	0.817	0.722
	Recall	0.785	0.719	**0.812**	0.748
	F1 score	0.740	0.723	0.814	0.726
Mid-way Prediction	Accuracy	0.670	0.617	0.768	0.639
	Precision	0.687	0.645	0.768	0.663
	Recall	0.734	0.626	**0.768**	0.649
	F1 score	0.710	0.632	0.768	0.645
Early Prediction	Accuracy	0.612	0.577	0.580	0.555
	Precision	0.611	0.590	0.577	0.572
	Recall	**0.749**	0.667	0.580	0.626
	F1 score	0.672	0.625	0.578	0.596

The RF model achieved the best performance in the late and mid-way prediction scenarios. The accuracy, recall, and precision reached 76% even in the mid-way prediction, a significant finding for making decisions on remedial actions. The high recall is another significant finding that indicates a high proportion of at-risk students can be detected.

Interestingly LR, which is often regarded as the simplest model, could best fit the early prediction scenario. The knowledge about students in the early period mainly came from the few classes and formative assessment events. A high recall is more desirable than a high precision as false negative (i.e. students predicted as normal are in fact at-risk) should be kept minimal.

The performance of DT and ANN are disappointing. One probable reason is that these two models are prone to overfitting or poor generalization in noisy datasets. The variables in the early prediction scenarios were low in information and high in noise. The ANN performance was also sensitive to the hyper-parameters related to the network architecture. These two machine learning models were omitted in the rest of the study.

4.2 The Effect of At-Risk Student Models

Table 2 displays the performance of the LR and RF models in predicting at-risk students according to three different models, namely below the mean score, below the 30 percentiles, and below the absolute score of 40%.

Table 2. The performance deviations according to the selected models of at-risk students

	Below Mean Score		**Below 30 Percentiles**		**Below 40%**	
At-Risk (N)	106		42		40	
Normal (N)	121		185		187	
	LR	RF	LR	RF	LR	RF
Accuracy	0.701	0.812	0.811	0.783	0.815	0.797
Precision	0.699	0.817	0.487	0.832	0.483	0.840
Recall	0.785	**0.812**	0.240	**0.783**	0.231	**0.797**
F1 score	0.740	0.814	0.299	0.719	0.296	0.738

In this experiment, the student group was divided into two subgroups according to the at-risk model. A smaller at-risk subgroup had more noise and therefore challenged the simpler LR model. The performance of RF was found to be quite steady across all the three models.

4.3 Rolling Prediction

The prediction accuracy is expected to increase as the course moves from one week to the next. The additional knowledge gained about the students should help come up with a more accurate prediction. Figure 4 shows the rolling prediction accuracy behaved as expected. The performance measured for a certain week used all the summative and formative assessment events and the attendance records in the past. The next grade refers to the coming summative assessment events, which occurred in weeks 6, 9, 11, 13 and the final assessment after the end of the course.

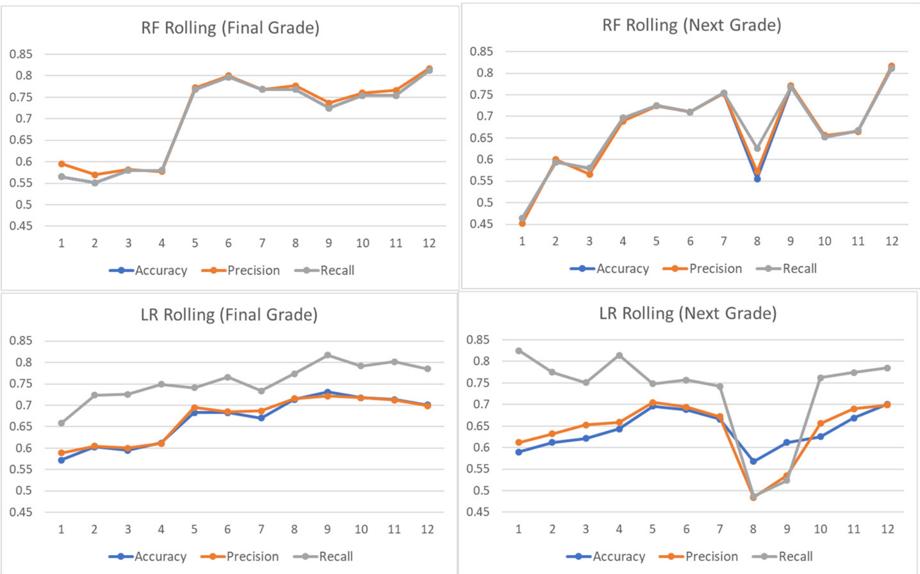

Fig. 4. The rolling prediction for the RF models (top) and the LR models (bottom). For each pair, the left-hand side shows the rolling prediction of the final grade, and the right-hand side shows the rolling prediction of the next summative assessment events. The labels on the x-axis are the week numbers. The y-axis represents the findings based on three performance metrics, namely accuracy, precision, and recall.

The scenarios of rolling prediction for the final grade were found steadily improving until the last week of the course. The three metrics of the RL model all reached over 80% at the end. The recall of the LR model performed comparatively, wandering about the 80% mark after week 8.

Predicting the grade of the next summative assessment event was found to be considerably harder. In Figure 4, the dip around week 8 was mostly attributed to the poor performance in the second summative assessment event in week 9. The objectives of the next summative assessment event should normally be associated with the teaching in the prior weeks. The design of the summative assessment, the effort in studying, the difficulty of the topics could all increase the uncertainty of the score of the event.

4.4 Formative Assessment and Summative Assessment

Table 3 compared the contribution of variables engineered from summative assessment and that engineered from formative assessment. Summative assessment was found to generally outperform formative assessment as expected.

In the late prediction scenario, formative assessment was found to be unhelpful or even disruptive. A full set of predictive continuous summative assessment variables was available, and there was no place for formative assessment. However, in scenarios occurring in earlier parts of the course, formative assessment was found to be useful as a predictor.

Note that as discussed in the previous sections, LR can perform well in simpler modelling tasks. It was found that LR outperformed RF when only summative assessment variables or only formative assessment variables were used. However, RF has the learning capacity to handle the added complexity of combining all the variables in one model.

Table 3. The contributions of formative assessment and summative assessment towards the prediction models of two machine learning techniques and two prediction scenarios.

		Mid-way Prediction		**Late Prediction**	
		LR	RF	LR	RF
Summative Assessment Used	Accuracy	0.714	0.623	0.780	0.812
	Precision	0.720	0.628	0.779	0.817
	Recall	**0.783**	0.623	**0.825**	0.812
	F1 score	0.745	0.625	0.800	0.813
Formative Assessment Used	Accuracy	0.603	0.594	0.612	0.638
	Precision	0.607	0.586	0.614	0.632
	Recall	**0.733**	0.594	**0.751**	0.638
	F1 score	0.662	0.588	0.671	0.634
Summative and Formative Assessment Used	Accuracy	0.683	0.797	0.701	0.812
	Precision	0.685	0.800	0.699	0.817
	Recall	0.766	**0.797**	0.785	**0.812**
	F1 score	0.719	0.798	0.740	0.814

4.5 Predictive Power of Variables

Table 4 shows the variables with the most predictive power in four different models. MDA was used as the metric for the evaluation. In the early prediction models, only formative assessment variables were available and as expected these variables were far more important than the ones related to attendance.

Table 4. The most important variables found in four models using MDA. The bracketed figures are the percentage of contribution of the corresponding variable towards prediction accuracy.

Early Prediction		**Mid-way Prediction**	
LR Model	RF Model	LR Model	RF Model
Formative Item Correct (0.57)	Formative Item Attempted (0.57)	Formative Item Attempted (0.35)	Summative Score (0.76)
Formative Item Attempted (0.34)	Formative Item Correct (0.43)	Summative Score (0.34)	Formative Item Correct (0.08)
Formative Item Attempted Ratio (0.02)	Formative Item Attempted Ratio (0.00)	Formative Item Correct (0.19)	Formative Item Attempted (0.06)
Formative Score (0.02)	Formative Score (0.00)	Formative Score (0.05)	Class Attendance (0.05)
Attended Class Early (0.02)	Attended Class Early (0.00)	Attended Class Early (0.04)	Formative Item Attempted Ratio (0.02)
Attended Class Early Ratio (0.01)	Attended Class Early Ratio (0.00)	Formative Item Attempted Ratio (0.02)	Attended Class Early Ratio (0.01)
Class Attendance (0.01)	Class Attendance (0.00)	Formative Submitted Early (0.01)	Formative Submitted Early (0.01)
Total Attendance Duration (0.00)	Total Attendance Duration (0.00)	Attended Class Early Ratio (0.00)	Total Attendance Duration (0.01)
Formative Item Attempted Ratio (0.00)	Formative Item Attempted Ratio (0.00)	Class Attendance (0.00)	Formative Score (0.00)
		Total Attendance Duration (0.00)	Attended Class Early (0.00)

Recall that the LR model outperformed the RL model in the early prediction scenario. The variables related to answered formative questions correctly (i.e., Formative Item Correct) were probably more important than the variables related to attempted formative questions (i.e., Formative Item Attempted). It is reasonable as the former directly measures the knowledge and the latter measured the motivation.

In the mid-way prediction scenario, summative assessment score became available. Recall that the RL model performed better than the LR model. The variable of the summative assessment score (i.e., Summative Score) was probably the most important. The formative assessment score was relegated to a minor variable.

5 Discussion and Conclusion

The study on the feasibility of short-term prediction of academic performance in a Zoom-supported course was completed. It explored the performance of machine learning techniques as the basis for building accurate prediction models. It proposed various prediction scenarios that would occur at different phase in a course and compared the model designs needed to make the best of the modelling variables available. In particular, the predictive power of variables and the relative strength of summative and formative assessment were studied.

The most effective models were mostly built on Random Forest (RF). RF was found to perform best in scenarios when there are many predictive variables available. The strength of RL for this task is largely agreeable with the literature. However, it was also found that Logistic Regression (LR) performed well in small and noisy datasets, such as early prediction scenarios. The poor performance of artificial Neural Network (ANN) came as a surprise. There were prior studies on early detection that found ANN performing satisfactorily (Chen et al., 2020; Olive at al., 2019). These studies did not make comparisons with the LR models and the developed ANN architectures could perhaps deal effectively with noisy datasets. Further research in this topic is needed.

The week-by-week rolling prediction enables continual monitoring of the at-risk group of students in a course. According to the findings, a better implementation of rolling prediction is to use a LR model for the early weeks and to use a RF model after summative assessment is available. A possible design for future work to explore is an ensemble model coupling LR and RF models. The ensemble model should learn from training data the timing of switching between the two machine learning models.

An at-risk student monitoring dashboard is an application that has integrated data collection, analysis, visualization, and interaction for the detection and management of student performance in a course. OU Analyse is an example (Kuzilek et al., 2015). The application provides several machine learning models for at-risk student prediction. It can combine disposition variables as well as those engineered from an online learning platform. There is a great potential of adding such a dashboard to the Zoom platform and other similar synchronous teaching platforms.

A major limitation of the study is the small sample size as only one course was included in the study. The generalization of the findings to another Zoom-based course is therefore questionable. The future work should include a few more courses of different disciplines. As far as the course is concerned, the student number of over 200 should be considered sufficiently large. Small size courses likely induce a higher noise level, and such courses should also be included in the future work.

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Gamification and Effectiveness of Different Digital Teaching and Learning Tools used in Online Tertiary Education Classrooms during the Pandemic

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Abstract
Purpose – This research compares and evaluates the success of gamification and the effectiveness of various digital teaching and learning tools used in motivating students in university classrooms in Hong Kong during the pandemic. The study also focuses on the psychological and physical behaviours of teachers and students towards the adaptability to game-based learning platforms and the success and effectiveness for English Language acquisition among university and college students in Hong Kong during the pandemic. In addition, it looks at the application of different technological aids and digital gaming platforms. The research further investigates the popularity and ease of applicability of different gaming tools in relation to the disciplines and contexts of English Language learning and teaching, with reference to the learners' and the educators' technological literacy and training received, and equipment support offered by educational institutions in tertiary education in Hong Kong.
Design/Methodology/Approach– The methodology of the research includes the collection of data from questionnaires and surveys distributed and interviews conducted among university and college students and teachers in Hong Kong, in corresponding to their perceptions, attitudes, motivation, interests, preferences, feelings of ease and other psychological responses to the application of different gaming tools for English Language learning and teaching.
Findings – It was found that most university students and teachers are comfortable using different gaming tools to enhance the interactive learning environment in English language classrooms. When students engage in creating games together, either competitive learning or collaborative learning can create an interactive classroom simultaneously. With the concept of level-up, learners are motivated to proceed to the next level or to being elevated to an advanced subsequent course. In this regard, learning becomes a process, and students are motivated to create the learning outcomes with their peers.
Originality/Value/Implications – The research explores the possibility and limitations of applying the notion of gamification in virtual classrooms. This accelerates future course development with the possibility of course redesign and assessment restructuring with a switch to the new mode of technology as the trend. It also provides a framework to the further study of the application of gamification in other subjects and different classrooms around the globe, with the reference to the motivating force and physical and psychological behaviours of individuals in the learning contexts in tertiary education.

Keywords: gamification, online learning, language learning face-to-face classrooms, motivation

1. Introduction

In the 21st century, the use of games has become a popular trend within adults and youngsters. Academics, scholars, educators, and practitioners have been discussing the incorporation of *gamification* in classroom learning, which is referred as an educational term or even pedagogy used in learning with games to improve students' English Language competence since it reflects an innovative and captivating learning activity (Redjeki & Muhajir, 2021). This research conducted aims at investigating the tertiary learners' and educators' perception and attitudes towards gamification in both online classrooms and face-to-face classrooms, during and before the outbreak of the pandemic in Hong Kong. This study also focuses on the effectiveness, practicality and limitations of game-based learning in motivating and engaging students towards effective and sustainable learning in remote and traditional classrooms in higher education in Hong Kong.

2. Methodology

Two sets of questionnaires were administrated and distributed to university and college students and teachers in Hong Kong studying and teaching in various English Language courses at different levels. Among the student respondents in questionnaires and surveys, a vast majority of them (90.7%) are undergraduate degree students from different disciplines and specializations taking English Language subjects across curriculum among different universities in Hong Kong during the pandemic era. More than half of them (63.2%) are currently studying bachelor degree programmes in The University of Science and Technology, followed by undergraduates from The Hong Kong Polytechnic University (23.7%), City University of Hong Kong (5.3%) and King's College of London (1.3%). A vast minority of them belong to the group of college students (5.2%) in higher education prior to their admission to universities, who are studying in associate degree and higher diploma programmes in HKU SPACE Community College (2.6%), HKU SPACE Po Leung Kuk-Stanley Ho Community College (1.3%) and HKCT Institute of Higher Education (1.3%). Among them, 37.7% of them are studying in undergraduate degree year 2, followed by 27.5% come from undergraduate degree year 1 and 26.1% from undergraduate degree year 3. Less than 9% of them are associate degree year 1 to year 2 and higher diploma year 1 to year 3 (Fig.1).

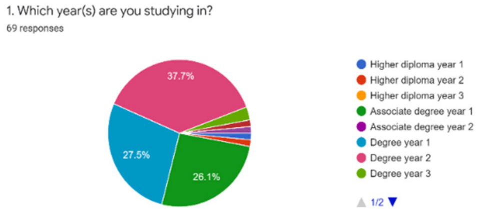

Fig. 1. Year and academic programmes of student respondents in questionnaires

Apart from education background and the level of competence in English Language acquisition, gender also plays a role as determinator of the competence and attitude towards game users in classrooms. Considering this variable, respondents are asked to indicate their gender in the questionnaires. Interestingly, a majority are males (72.4%) while a minority are females (26.3%). In addition, 90.7% belong to the student group whereas 9.3% are English Language teachers in universities and colleges in Hong Kong (Fig. 2). Further data analysis later reflect how demographic and other gender variants can govern the competence of digital technology, practicability of gamification and thus the effectiveness and success of gamification in classrooms, which influences the level of interactive learning environment and student-teacher relationship in both online and face-to-face classrooms.

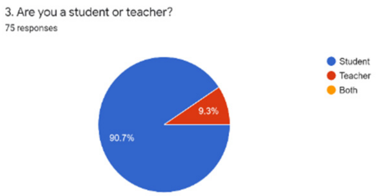

Fig. 2. Proportion of student and teacher respondents

3. Results and Findings

This research juxtaposes the transformation of physical and psychological behaviours of learners and educators towards various game-based platforms in online classerooms from the first semester shortly after the outbreak of Covid-19 till the following academic years and face-to-face classrooms before the pandemic in Hong Kong, with reference to effectiveness of learning, student engagement, motivation and incentive, motivation and effective; and limitations and suggestions. It is concluded that most university students and teachers have established the habit in using Zoom and find it at ease of exploring other digital learning and teaching platforms influenced by the pandemic. Game-based learning is an interactive learning methodology and instructional design strategy that integrates educational content and gaming elements, by delivering interactive, game-like formats of instruction to learners (Fridolin et al., 2019). Moreover, such learning integrates aspects of experiential learning and intrinsic motivation with game applications that have explicit learning goals, thereby allowing learners to engage in complex, problem-solving tasks and activities that mirror real-world, authentic situations (Fridolin et al., 2019). With simulation and physical artifacts, physical classmates could be simulated during the pandemic period.

3.1. Learners' perception and attitude towards gamification among universities and colleges in Hong Kong

Among the student respondents, a vast majority (87%) of university and college students indicate positive perception towards the effectiveness of learning in classrooms through gamification. On the other hand, only 1.4% disagree learning through games is effective. More than one-tenth (11.6%) totally agree that learning through games is effective while more than half of them (55.1%) strongly agree such teaching strategy is effective. More than one-third (31.9%) believe that it is somehow effective (Fig 3). In the view of the perception of effectiveness of gamification towards classroom learning from students' perspective, a majority (73.9%) think that incorporating games is a constructive means to learn. 15.9% regard this approach as the most effective, followed by 58% perceive gamification is very effective in tertiary education and 18.8% are neutral. 5.8% disagree that gamification is an effective pedagogy in helping university and college students to learn better while 1.4% regard it as the least effective way (Fig. 4).

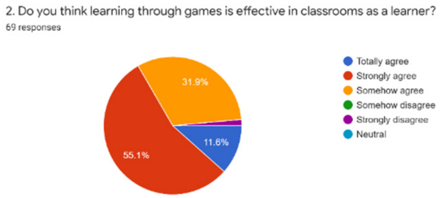

Fig.3. Perception of student respondents towards effectiveness of gamification in classrooms

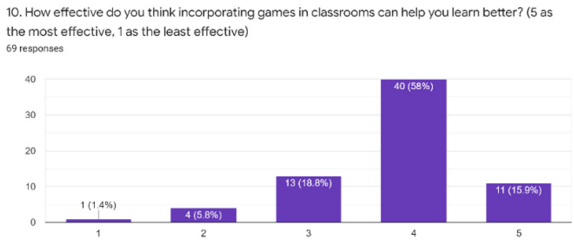

Fig. 4. Degree of effectiveness of gamification towards learning from the perspective of student respondents

In correspondence with the measurement of the effectiveness of learning in online classrooms, students' perception in being motivated to learn through games is a considerable factor contributing to the conclusion whether the learning experience is effective or not. 94.2% of student respondents reveal that learning through games is a significant incentive to motivate them to participate fully in classrooms. In contrast, 2.9% disagree incorporating games in classrooms is effective in motivating students to learn better while another proportion of 2.9% are neutral towards gamification in classrooms. Regarding the degree of effectiveness of gamification in motivating students to learn better, a vast majority of the student respondents (76.8%) hold the view that learning through games in university classrooms is the most effective (15.9%) and very effective (60.9%) respectively as a motivational drive to learn better. 15.9% are neutral whereas 7.2% reckon it as not effective (5.8%) or the least effective (1.4%) pedagogy in motivating learners (Fig.5).

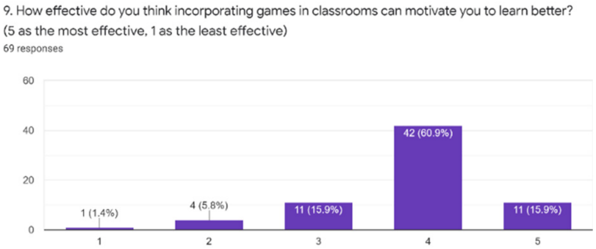

Fig. 5. Degree of motivational drive by gamification from the perspective of student respondents

More than half of them (53.8%) believe the major reason is that learning through games in classrooms is fun, followed by 26.2% regard visuals and colours are more appealing than plain words which come as the second most important concern. Interestingly, more than one-tenth of student respondents (10.8%) explain that they want to win their fellow classmates which demonstrates peer influence as an important factor in governing the level of class participation. Less than one-tenth (7.7%) feel that gamification encourages them to accomplish tasks through teamwork, which in return motivate them to learn with peers. 1.5% believe that playing games online has been the trend and therefore it is necessary to incorporate games in classroom learning (Fig. 6).

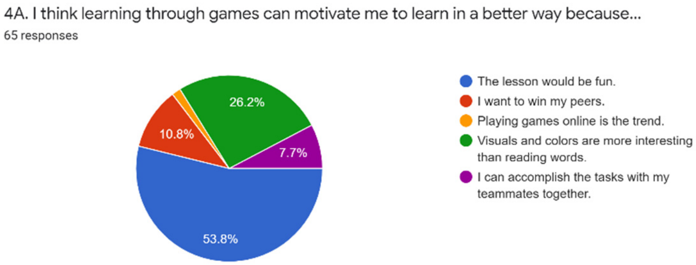

Fig. 6. Reasons explains why gamification can motivate students to learn better

Meanwhile, just 5 student respondents disagree that learning through games can motivate them to learn better. Among respondents who show a negative correlation between gamification and motivation, 40% reckon this can be justified by the common perception that learning is always dull and boring. One-fifth (20%) indicate that even games are incorporated in classrooms, they are incomparable to the fun of video games that they are playing in pastime. Similarity, one-fifth (20%) believe that learning in classrooms should be serious and the other one-fifth (20%) explain their concern that they do not want to communicate with classmates through games (Fig. 7).

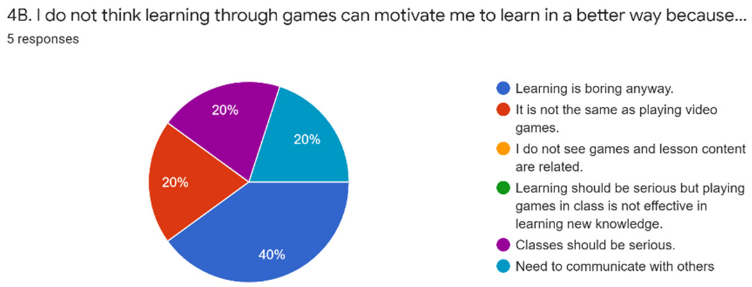

Fig. 7. Reasons explains why gamification cannot motivate students to learn better

3.2. Students' recount of university teachers' experience in using game-based platforms and other innovative digital tools in online classrooms and face-to-face classrooms for English Language subjects

Among all the game-based platforms, more than half of the student respondents (55.4%) recall the experience of having their English Language teachers using "Kahoot" in their virtual classrooms in their universities or colleges in Hong Kong in both online classrooms during the pandemic and face-to-face classrooms before the pandemic. Shared document serves as the second most common digital tool in the language classrooms, which constitutes almost one-fifth (18.5%) of students have the experience in being asked to use shared document. 7.7% of them have experienced roleplays in English Language classes, followed by 4.6% have used storyboards before. A small minority (3.1%) have used Class123. The other 3% indicate that they have been instructed to use Soqqle and Flipgrid, with 1.5% students out of 3% revealing their English Language teachers have used Soqqle and Flipgrid respectively. 5.5% reveal that they have never experienced any digital learning tools in classrooms except Zoom as the major communicative classroom platform during the pandemic in Hong Kong (Fig. 8).

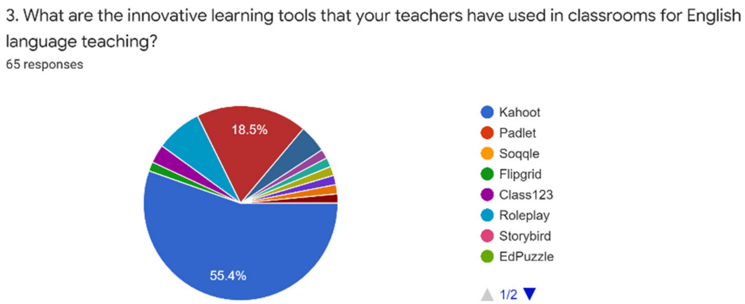

Fig. 8. Students' recount of using different game-based platforms in English Language learning experience

Kotob and Ibrahim (2019) points out that teachers experiment different digital teaching strategies which focus on visual such as images, paintings and shapes; auditory through rhythms, chants and tones; and kinesthetic like body movement and gestures, in order to help students to stay engaged with the taught materials in the remote learning. Among all, one of these teaching strategies is learning through gamification. With reference to the comparison of frequency of usage of various games in online classrooms and physical classrooms, 34.8% of student respondents believe that teachers have been incorporating games in online classrooms as much as face-to-face classrooms. While 33.3% claim that there are more games to be designed in physical classrooms, 26.1% recall more games have been incorporated in online classrooms during the pandemic instead. Only 5.8% cannot recount their learning experience in relation to learning through games in classrooms (Fig. 9).

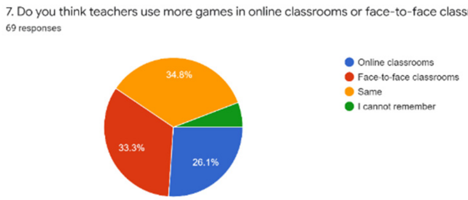

Fig. 9. Students' comparison of their teachers' usage of games in online classrooms during pandemic and face-to-face classrooms before pandemic

3.3. "Kahoot" is favoured as the most popular game-based platform in digital learning among university students and teachers in Hong Kong

Among all the game-based platforms, it is found that Kahoot is regarded as the most popular game by English Language teachers in both online and face-to-face classrooms. It has a user-friendly interface that requires low level of technical expertise and the use of "Kahoot" increases undergraduate students' motivation because of its easy-to-use implementation (Campillo-Ferrer et al., 2020). According to Campillo-Ferrer's research from the before and after tests, "Kahoot" was concluded to be one of the most effective digital tools which encouraged creativity and innovation (2020). In the studies, it was found that active participation of students stimulates their imagination and their creative capacity to make their own tests and learn from those made by their teachers and classmates. It successfully increases students' engagement and motivation to learn and their ambitions for success as it creates a stimulating and competitive environment in which students actively participate. In fact, both students and teachers can create a positive learning experience in a clear and understandable way using only pictures, video and questions to foster an intensely innovative social learning experience. Furthermore, "Kahoot" is easily accessible by any device with internet connection, smart phones, tablets or laptops. It thus promotes a type of synchronous interaction that encourages real-time collaboration and fosters a sense of community, promoting participatory evaluation that favors the development of cross-disciplinary skills (Campillo-Ferrer et al., 2020). Furthermore, "Kahoot" and other similar innovative tools been shown to improve students' ability to grasp the meaning of new information, ask questions, make decisions, and draw conclusions that help achieve learning goals and expected outcomes. The results obtained in also confirm students positively value the use of this digital platform, which can encourage the adoption of these motivating ICT proposals in similar contexts later (Campillo-Ferrer et al., 2020). With regards to the data on the digital competence of learners, it should be noted that the participants welcome these online proposals and feel able to master this platform in terms of understanding game options, basic instructions and question formulations. More importantly, no specific training or complex technical knowledge is required (Campillo-Ferrer et al., 2020).

3.4. University students' comparison of the effectiveness of gamification in online classrooms during the pandemic versus face-to-face classrooms before the pandemic

In this view, there is a significant remark that the popularity of gamification in classrooms lies in face-to-face classrooms more than online classrooms, while there is a similar proportion of student respondents reckon that teachers use games in online classrooms as much as face-to-face classrooms. This illustrates that gamification is not an exclusive approach to be commonly used in virtual classrooms by English Language teachers in universities and colleges in Hong Kong only during pandemic era. On the contrary, the contexts and localities of teaching are not a factor in governing whether they adopt gamification in classrooms or not, with or without the impacts from the pandemic and social distancing measures in the society. Considering a small proportion of students fail to recall their learning experience as shown from the questionnaires, the limitations of the effectiveness of using gamification in teaching and learning will be further analyzed in later section.

4. Implications

4.1. The necessity and need for gamification in online university classrooms during the pandemic and the possibility of transformation from traditional teaching practice to game-based learning (GBL)

The promotion of game-based learning (GBL) has undoubtedly changed academic environments and traditional teaching styles by significantly modifying the roles of teachers and students (Campillo-Ferrer et al., 2020). In particular, GBL implies more active participation in these learning processes with regards to students, who responds more effectively to their current interests while improving digital literacy and promoting quality and sustainable education (Campillo-Ferrer et al., 2020). To achieve these objectives, the emergence of new teaching and learning models has encouraged educators, as social actors, to adapt to the needs of learners in order to create conditions suitable for developing more motivating and innovative practices (Campillo-Ferrer et al., 2020). Today, remote controls are no longer necessary because smartphones, tablets or laptops favor the implementation of these systems due to wireless connections, applications and websites. Therefore, content knowledge and fun can be merged into daily lessons without the need for other intermediate devices due to the advancement and application of Information and Communication Technology (ICT). On the Internet, a variety of high-quality online platforms can be found such as “Kahoot”, “Socrative”, “Quiz”, “Acadly” or “PollEverywhere”, inter alia (Campillo-Ferrer et al., 2020).

However, it poses a challenge to discover the dichotomy and contraction between the internalization of necessity of gamification in various modes of classrooms by students and teachers, and the success of gamification in virtual classrooms versus face-to-face classrooms in enhancing the effectiveness of learning and motivations of university students, especially during the pandemic in Hong Kong. Some interviewed students hold the view that online games are equally popular in face-to-face classrooms to online classrooms. Likewise, games in face-to-face classrooms are as much as being adopted by teachers before the pandemic in Hong Kong when compared to online university classrooms during the pandemic in Hong Kong. While it may be deduced that the trend of incorporating different games in university classrooms to make the classes lively and fun is commonplace due to the global pandemic, some students reveal that the process of gamification is actually smoother and more effective in face-to-face classrooms even before the pandemic when online mode of classes have not been adopted. This conforms to the earlier finding that more than one-third of student respondents (34.8%) in the questionnaire highlight that their teachers have been incorporating games in online classrooms as much as face-to-face classrooms. Similarly, slightly more than one-third (33.3%) recall that more games have been incorporated in their formal face-to-face classes in English Language acquisition. While it may be expected that gamification is getting more popular in online classrooms as digital learning has become the prevailing norm in education across different disciplines and sectors accelerated by the global pandemic, games of different categories and pedagogy have been popular in fact for long in face-to-face classrooms even before the outbreak of Covid-19.

Rather than a surge of popularity of gamification in virtual classrooms, only approximately one-quarter (26.1%) of the student respondents recount their memory of having more games in online classrooms in their learning experience in universities or colleges during the pandemic period in Hong Kong aforementioned. A few interviewed students also conclude that games in online classes cannot serve the purpose of attracting students’ attention during class fully, which means that gamification is a less dominant and significant driving force in motivating students to learn in virtual classrooms since face-to-face presence promises students’ attention span. In addition, it is suggested there is a possibility that some university and college students may just simply ignore the game playing part in class during online lessons. However, teachers can ensure every student is engaging in the assigned games in face-to-face classrooms due to the physical presence. In this light, gamification is not the solely effective way to facilitate students’ interaction with their fellow classmates and teachers as much as we expect. Games cannot guarantee all students are entirely participating in the whole lesson during either online or offline classes.

4.2. Students' preference of various gaming tools and perception of the reasons for English Language teachers not adopting gamification approach

Regarding the categories and nature of games to be incorporated in virtual learning, almost half of the student respondents (47.8%) claim that they prefer both competitive and collaborative games. More than one-fourth (26.1%) prefer competitive games, which compose of the competitive elements among classmates. Level-up games in which students need to proceed to different levels are only popular among less than one-fifth (18.8%) of the student respondents. Collaborative games come to the least popular, in which only 7.2% of university and college students in Hong Kong prefer teamwork during class activities (Fig. 10).

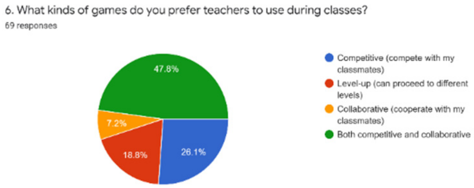

Fig. 10. Categories of games preferred by student respondents

It is found that university and college students in general have the perception that time is the dominant factor for the absence of gamification in university classrooms. Less than half of them (41.8%) believe that teachers lack time to prepare for games to be incorporated in classrooms, especially during the pandemic era. However, almost one-fifth (19.4%) perceive their English Language teachers are not synchronous with the concurrent trend and thus gamification in classrooms is not adopted. 16.4% account their teachers may not understand the importance of games, while 10.4% interpret their teachers may not know much about games and 9% believe their teachers may not comprehend the importance and need of games. 1.5% indicate the absence of games in classrooms is due to the difficulty in designing different games for some specific subjects like language, literature and statistics (Fig. 11).

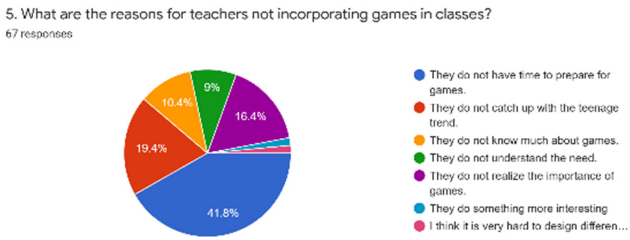

Fig. 11. Reasons of teachers not incorporating games in classrooms from students' perspective

4.3. University students' perception and attitude towards gamification in general in English Language teaching classrooms in Hong Kong

It is interesting to find out that students in general tend to equalize whether lessons are fun and interesting as the determinators for their intrinsic and extrinsic motivation in learning. Most of them assess whether their learning experience is effective or not mainly on the basis whether their teachers can keep their attention long during the entire classes. In addition, physical sensations to physical body and positive psychology both play the vital roles in motivating university students to learn better in classrooms. Apart from the fun nature of games as the chief motivator, the second most important reason to support games to be incorporated in classroom learning is due to the intrinsic nature that visuals and colours in the design of games are more sensationally powerful than plain words, followed by learners' desire to win their peers as the third key cause in their conclusion that gamification can motivate them in both virtual and face-to-face classrooms. In other words, it is obvious that traditional classrooms with teachers' one-way lecturing and teacher-centered classrooms are no longer enough to satisfy students' need for innovative learning as the new trend nowadays, especially with the acceleration of digital learning impacted by the outbreak of Covid-19 in the globe. Kapp (2012) identifies gamification as "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems".

An active learning context refers to the various learning approaches and instructional methods such as experiential learning, collaborative learning, cooperative learning, case-based, inquiry-based, problem-based, team-based and game-based learning. These different models cover the subset of active learning. Hence, active learning is an umbrella concept that encompasses the different learning approaches and instructional methods of learning (Fridolin et al., 2019). As aforementioned, almost half (47.8%) of the university and college students respond they prefer both competitive and collaborative games, followed by competitive games as the second most popular type of games (26.1%), then level-up category of games (18.8%), and finally collaborative games (7.2%) come to as the least popular kind. From the collected data, it is illustrated that university students have greater expectation on the variety of games that they can be exposed to in classroom learning owing to the commonplace digital learning and technological competency. Competitive games in which students compete with their fellow classmates and level-up games require players to proceed to advanced levels progressively are more popular than collaborative games comparatively. By examining the demographic background of the targeted respondents and interviewees, these groups of university and college students belong to a more advanced and mature learners than the younger learners before the admission to tertiary education. This can be explained by the psychological behaviour of learners, who are academically and mentally stronger students from dominant universities and colleges in Hong Kong, and simultaneously having the experience in surviving through public examinations, tend to be more used to competitive learning environment and thus are relatively more self-driven to win. On the other hand, collaborative games such as games relate to teamwork are regarded as less popular among these student groups. This can imply these student respondents in general may imagine their fellow classmates as academic rivals rather than teammates to collaborate and cooperate with. Level-up games are also popular due to the sense of achievement and accomplishment that students can attain by proceeding to another level, which can also be impacted by the prevailing level-up concept designed in video games that students are always exposed to nowadays.

Many studies have proved that friendships play a critical pivot on students' social, emotional, and cognitive development. Liao et al. (2018) found that about 50% of students' achievement-related comparisons were made with their best friends and they often prefer to compare themselves with friends. Moreover, some studies indicated that friendship relations are a key role in maintaining positive interactions and alleviating negative interactions among students in a learning activity. Theoretically, friendship relations are beneficial for students situated in competitive learning environments, but friendship relations are still absent in relevant studies, especially on the surrogate competition (Liao et al., 2018). Apart from friendship, some studies have also shown that gender differences can impact the preference over a competitive learning. According to Liao et al. (2018), boys are more highly motivated to participate in game-based learning environments than girls and tend to have higher incentive to attain higher scores in competitive games than girls. This means gender stereotypes exist and thus play a role in students' learning attitudes, which corresponds to the demographic background of student respondents which are represented by 72.4% males and 26.3% females aforementioned. When students are involved in an effort-demanding activity like competitions, they need to improve their learning status to win and thus are guided to realize that winning is closely correlated to the level of effort they exert. This cause-and-effect relationship is helpful for the establishment of a positive attitude towards motivational learning (Liao et al., 2018), which is enabled by competitive gams in classroom learning.

4.4. University teachers' perception and attitude towards gamification in virtual English Language teaching classrooms in Hong Kong during the pandemic

In order to analyze from a more holistic view in the practice and success of gamification in university classrooms in Hong Kong during the pandemic, data from English Language teachers is also collected for university teachers' perspective towards the usage of games in classrooms. It is found that a majority of teacher respondents (62.5%) agree that gamification is an effective means to motivate students in universities and colleges to learn better, with 25% totally agree and 37.5% strongly agree that incorporating games in classrooms is an effective approach to motivate students to learn better. In contrast, more than one-tenth (12.5%) strongly disagree that gamification is successful in motivating students while one-quarter (25%) are neutral towards gamification in both online and face-to-face classrooms (Fig. 12).

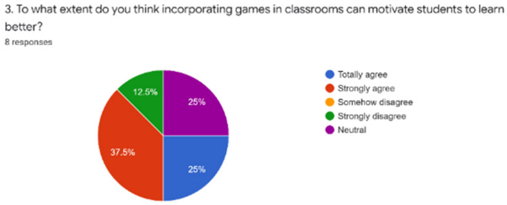

Fig. 12. University teachers' perception towards gamification in motivating students to learn better

It is clearly indicated that a majority of teacher respondents (62.5%) hold the belief of the necessity of positive reinforcement towards student motivation with the use of gamification in both online and face-to-face classrooms among universities and colleges in Hong Kong. However, the comparative findings between student respondents and teacher respondents also illustrate distinctive and different perceptions and attitudes towards learning through games among the two groups. As shown from the data analysis aforementioned, a majority of students (73.9%) think that incorporating games is a constructive means to help their effective learning in English Language classrooms, with the major concern about whether classroom learning is fun and interesting, which constitutes more than half of student respondents' (53.8%) need as learners for second language acquisition. In addition, almost all students (94.2%) claim that games act as remarkable incentive to draw their attention in classes of different modes and thus drive them to learn dependently inside and independently outside classrooms. In contrast, viewing the teachers' attitude towards the incorporation of games in both virtual and physical classrooms, more than half of university English Language teachers (62.5%) internalize the importance of gamification and other digital teaching tools as the current and upcoming innovative trend and thus there is a need to adopt a more interactive approach for students by devising new pedagogy in relation to digital technology in order to supplement or even replace one-way lecturing in traditional classrooms. According to Kotob and Ibrahim (2019), systems that only focus on lecturing and other traditional teaching strategies produce passive learners. "Spoon feeding" techniques in traditional classrooms tend to suppress students' creativity and neglecting their strengths as students are highly dependent on their teachers' lecturing instead of independent thinking (Kotob and Ibrahim, 2019). One-way lecturing also demotivates students to learn effectively if lessons are found to be dull and boring. In general, students prefer games to be incorporated in all classrooms more than teachers, given the intrinsic nature of collaborative and competitive games as motivators in getting students to work with peers, with 31.7% difference regarding the popularity of game usage between university students and teachers.

The statistics also demonstrate that all teacher respondents have the experience in running their English Language classes with gamification, as shown from the questionnaires that none of any individual teacher respondent claims he or she has never used games as teaching tools in university classrooms (Fig. 13). Nevertheless, when it comes to the practicality and frequency of the usage of games in English Language contexts, only half of them (50%) incorporate gamification in classrooms generally for a few times every semester for English Language teaching. If there are 13 to 14 weeks in every semester, it is implied that only approximately 15% to 35% of their total class time have been devoted to the practice of gamification in university classrooms. One-quarter (25%) recount that they include the elements of games in their English Language courses for more than half of the semester, which means this group of teacher respondents have spent half of the class time on incorporating games in university classrooms for students. Meanwhile, only more one-tenth (12.5%) design their English Language classes once every week and the other 12.5% conduct games in classrooms once every two classes respectively.

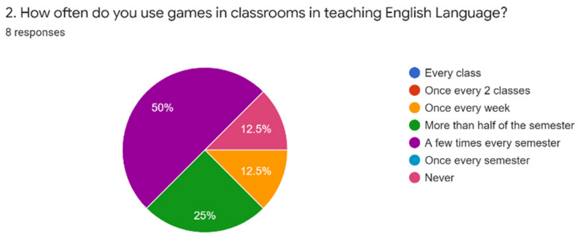

Fig. 13. Frequency of the usage of game-based platforms by teacher respondents in each semester

While a vast majority of university teachers (87.5%) reckon incorporating games in classrooms of any form is constructive in helping students to learn more effectively and positively (Fig. 14), it is indicated that there is also a majority of 75% teacher respondents believe games motivate students to participate more fully in class and learn better (Fig. 15). On the contrary, 12.5% of university teachers think gamification is not effective for students to learn better while 25% regard gamification cannot motivate students. It is concluded that there are striking differences between learners and educators in universities and colleges in Hong Kong, with reference to students and teachers' perceptions and attitudes towards the necessity and the effectiveness of gamification towards effective learning and motivator of learning.

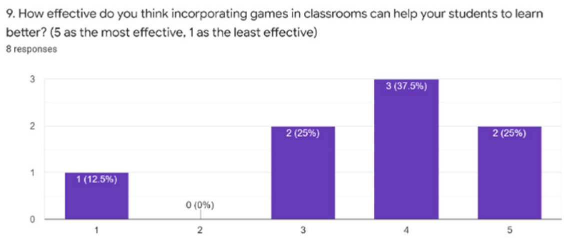

Fig. 14. University teachers' perception of gamification towards students' effective learning

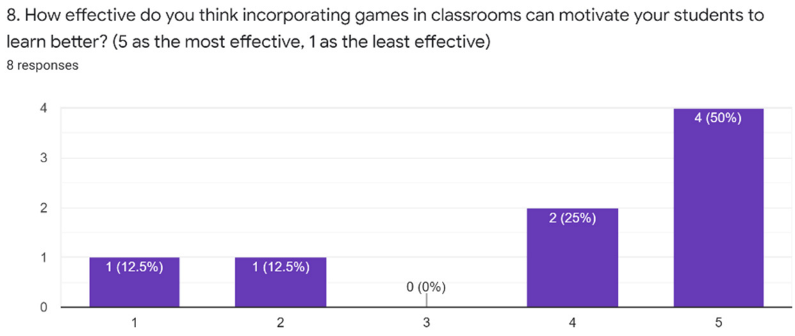

Fig. 15. University teachers' perception of gamification towards motivating students' learning

4.5. University teachers' comparison of the effectiveness of gamification in online classrooms during the pandemic versus face-to-face classrooms before the pandemic

In terms of effectiveness in using games online and face-to-face, most interviewed teachers believe that student engagement is the major concern. It is easier for teachers to engage with students in face-to-face classrooms due to their physical presence in concrete settings. On the other hand, it is harder to build rapport with students when the lessons go online, making teachers' assessment of students' learning progress more difficult. While students can switch off cameras on Zoom in virtual classrooms, teachers can walk around in the face-to-face classrooms to establish a sense of presence. Thus, implementation of gamification becomes more inclusive for each student in face-to-face classrooms, in which both active and passive learners are more motivated by gamification in physical classrooms, making learning more direct and effective. Nonetheless, there is a possibility that gamification can exclude the passive learners in online classrooms since it is more challenging for the teachers to supervise every student online. Meanwhile, a few interviewed teachers advocate that the ease of incorporation of games in online classrooms and face-to-face classrooms are both at a similar level. The most dominate reason relates to the positive psychology among university students that learners are in general attracted by the nature of games and fun lectures. Furthermore, the content of the lecture is always very much the same and materials are delivered via the similar platform.

4.6. Limitations of gamification in remote and face-to-face classrooms

Most of the student interviewees hold the view that there would be differences in respect to the effectiveness in using games in online in face-to-face classrooms. Most of them reckon that gamification is more effectively implemented in face-to-face classrooms before the pandemic rather than virtual classrooms during the pandemic in tertiary education in Hong Kong. Interestingly, it is generally believed that learning through collaborative games is more effective in face-to-face classrooms than virtual classrooms as shown from the fact that most student interviewees internalize the notion that face-to-face classrooms promote collaboration and effective communication in comparison to remote learning. Apart from collaborative games, it is also stated that competitive games online may be less fun and interesting than games in face-to-face classrooms, explained by the difficulty of online classrooms in establishing a competitive environment to encourage students to engage in competitions. Comparatively, face-to-face communication enables learners to interact and accomplish given tasks collaboratively in an easier and more comfortable way, providing the concrete physical settings which allow spontaneous and direct communication instead of potential communication barriers in intangible virtual channels. Hence, face-to-face classrooms facilitate both collaborative and competitive games more effectively in helping and motivating students to learn better than online classrooms.

In addition, online classrooms pose a challenge for teachers to create a positive and proactive learning atmosphere and thus is more difficult to set up the mood for game playing in virtual classrooms. Furthermore, the difficulty in implementing gamification to all students in online classrooms without excluding any passive learners is a crucial hinderance for student engagement. This includes the constraint in monitoring whether students are following house rules during online classes since some students can possibly turn off the cameras and mute themselves. One interviewed student cites an allegory that lecturers can spot out any student in physical classrooms who is not paying attention and thus the internalization that students should listen and respect the lecturers can in return facilitate students to concentrate better and reinforce students' full participation in face-to-face classrooms. One interviewed student has internalized the idea that online learning is dull and boring anyway and he is always distracted at home especially when he is sitting in a comfortable private area. It is generally believed among university students that they and their fellow classmates are more proactive in face-to-face lessons. This corresponds to some interviewees who proclaim that learning through games would be more "interactive, exciting, fun and attractive" with face-to-face and direct communication since the sense of student engagement increases behaviorally and emotionally in physical classrooms. It is also said that face-to-face classrooms can trigger more interactions between teachers and students and among students, which result in better student-teacher and student-student rapport.

On the other hand, the technological nature of virtual classrooms hinders the effectiveness of incorporation of games in digital learning experience. Among the interviewed students, it is found that they sometimes experience delay of response from teachers and classmates due to internet connection problem in remote classrooms, and thus reckon face-to-face learning to be more effective and direct.

4.7. The gap between university teachers' acknowledgement of the vitality of gamification in classrooms and the frequency of its usage in practicality

Given most university teachers recognize gamification as a constructive, effective and innovative means in facilitating students' learning, it is indicated that only 12.5% of teacher respondents incorporate games in their English Language courses once every week and once every two classes respectively. Likewise, none of any teacher respondents disagrees that gamification in classrooms is effective in motivating students to learn (Fig.15). The limitations of the practicality of gaming in both online and face-to-face classrooms can be justified by numerous obstacles in adopting gamification in university classrooms and other digital teaching tools. A large majority (75%) of teacher respondents hold the view that one major hinderance in incorporating games in classrooms is due to the tight teaching schedules (Fig. 16). Half of them (50%) believe that there is lack of trainings and resources received and somehow games and the content of courses are not interrelated (Fig. 16). The third most common limitation (37.5%) is that there is lack of access to different software and tools to support the learning through games in classrooms (Fig.16). It is unavoidable that the use of realia and concrete props in classrooms are unlikely in virtual classrooms during the pandemic. Therefore, implementation of gamification in online classrooms requires more institutional support, trainings to be received and know-how of the technology than that in the status quo, which further limit the feasibility and scale of incorporating games in classrooms during the pandemic.

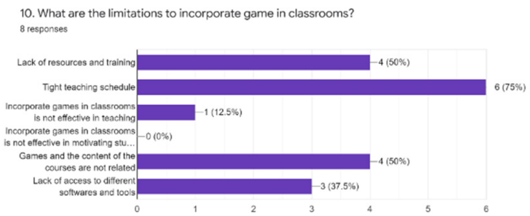

Fig. 16. Reasons of the absence of games in classrooms from teachers' perspective

4.8. Effectiveness and practicality of incorporating games in online classrooms versus face-to-face classrooms

Regarding the kinds of innovative teaching tools used in classes so far, most interviewed university teachers name a few including "Zoom polling", "Zoom whiteboard", "Kahoot", "Padlet", "Word Clouds", "Everything Poll", "graph Drawing", and "Lucky Draw". It is also highlighted that "Kahoot", "Padlet", "Spotify", "Word Clouds" and "Lucky Draw" are their preferred tools in both online and face-to-face classrooms for English Language teaching in universities and colleges in Hong Kong. From the results of interviews of teacher respondents, it is revealed that university teachers who deploy the concept of gaming in classrooms are in the purpose of enhancing spontaneous interaction and participation among students. It is also relatively easy for both teachers and students to use these game-based tools. On top of the interactive nature of gaming in classrooms, concepts can be visualized to students more easily and effectively with colours, symbols, graphs, shapes, videos and music through games.

In addition, the interviewed teachers hold the belief that games are catchy to students' attention and teachers can make use of gamification to monitor whether students are attentive in class at that time. However, one interviewed teacher holds an opposite view by raising her concern that there is a possibility that some students may feel harassed by the compulsory gaming in classrooms and students may also believe learning should be serious instead. Most interviewed English Language teachers explain the usage of games in classrooms can be hindered by the fact that the application of games and other digital tools rely too much on the content of the subject knowledge at that time. At times, ideas and inspirations from games can be interrupted by the lack of originality. Besides, the unstable internet connection for teachers and all students makes smooth adaptation of games in online classrooms during the pandemic even more difficult.

While gaming tablets and social media have been a major part of students' life, teachers face a significant problem towards students' motivation and achievement inside classrooms. Learners get easily distracted and show a loss of interest, and communication between students and the teachers becomes remote and fragile, especially with the distancing learning during the hit of pandemic (Kotob and Ibrahim, 2019). In particular, some teachers even find the digital platforms discouraging, as they have to do extra work to adjust the pace of the class to achieve a better understanding of the content. This requires enormous effort both inside and outside the classroom in order to integrate the digital content into lesson plans. This also requires the intensification of educational adaptations made in classrooms to promote content learning by all students in a comprehensive and meaningful way. Another disadvantage pointed out in some studies is linked to the negative attitude of some students to these digital challenges, since not all students prefer to play an active role in classrooms (Kotob and Ibrahim, 2019). In fact, some of them feel more comfortable taking notes and studying content after class without using their mobile phones for academic purposes because they fear making mistakes in public when using this digital resource or not feeling supported by their peers when asked about content previously worked on in public (Kotob and Ibrahim, 2019). Further research and information on the application of these innovative proposals in higher education contexts is therefore needed to better understand and adapt these ludic strategies to the main interests and demands of students in higher education.

5. Conclusion and Limitations

With the research analysis, gamification in classroom learning has been an unavoidable trend in education. With data collected from both learners and educators towards English Language learning in tertiary education in Hong Kong, the future research can be extended to compare the data analysis from both pre-and post-tests, with the integration of different games for experiments into the teaching process to assess the level of students' active participation and motivation towards a more interactive and stimulating environment. It is also recommended that more resources, trainings and technical support can be offered by the authorities and educational institutions to pursue the sustainable game-based learning and provide a more engaging and interactive environment for learners in the new technological era.

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Blended Learning as an Innovative Modality for Communication Theology: Assessing Achievement and Motivation

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Abstract

Purpose – Communication is a fundamental principle and essential dimension of theology. The Catholic Church encourages theological institutes, priests, and seminarians to be well informed, critical, and creative users of information and communications technologies (ICT). The recent advancements in ICT in education make its integration imminent in theological institutes. The theological institutes, at present, mostly use conventional or traditional face-to-face teaching methods. The researcher introduced a blended learning course and carefully studied its outcomes. This paper seeks to explore the student achievement and motivation for learning Communication Theology using a blended learning modality.

Design/methodology/approach – A brand-new relevant theology subject — Communication Theology — was taught in Saint Peter's Pontifical Institute of Theology, Bangalore, using a blended learning lab-rotation model for one semester. The blended learning course in this study was designed using the ADDIE (analysis, design, development, implementation, and evaluation) model, developed, implemented and evaluated for 21 first-year theology students. The researcher used descriptive (online questionnaire) and quasi-experimental (one-group pretest-posttest) methods to assess student achievement and motivation. The online questionnaire contained the statements on a 5-point Likert scale, and the pretest-posttest questionnaire included the questions on subject knowledge.

Findings – The results revealed a statistically significant difference in achievement, and that students were motivated and readily adapted to learning through MOODLE. They were highly satisfied with the blended learning course. The positive results revealed that the future priests were willing to integrate ICT into their life and mission.

Originality/value/implications – This micro-study and the first attempt to implement blended learning for the *Communication Theology* course explored the possibility of its implementation in theological institutes. This research proposed a new student-centred teaching-learning method and opened an era of ICT integrated education in the theology curriculum. The increased student achievement and motivation enhance their engagement and enable seminarians to gain a deeper understating of the subject. Further, it augments the capacity to unfold the human potentials as they manage to learn independently.

Keywords: communication theology, seminarians, blended learning, achievement, motivation.

1 Introduction

Information and communications technology (ICT) have become integral parts of our daily lives, reshaping almost every dimension of our life: the way we think, relate with one another, learn and do business, and even perceive ourselves. With their greater availability and affordability, they bridge gaps in this digital age, helping to transmit and process information between and among different parts of society. Widely accepted, ICTs serve as the underlying infrastructure necessary for economic and social development. Thus, the inevitable influence of ICTS in socio-political, economical, and even spiritual domains, is evident.

The integration of ICTs in religious practice, especially in Catholic education and formation, is a need of the time. Accordingly, the Church has been encouraged to adopt ICT and blended learning in their institutions and daily practices. Consequently, the Pontifical Council for Social Communication in the Catholic Church attests that the ICTs should not be treated as optional because they offer enormous benefits when used as tools and not as ends in themselves (Foley, 2002).

Integrating ICTs in religious formation has become inevitable, and the Church strongly admonishes future priests to be comfortable in using ICTs. Eilers (2014) documented more than forty documents that the Church published on the necessity of communication, social communication, and the need to integrate communication in life and practice. The formation houses and theological institutes have significant responsibilities to help priests integrate ICTs into their life and practice. Thus, the post-millennials who enter seminaries prepare for their mission with natives of the digital culture. At this juncture, it is imperative to find the possible ways of integrating ICT through the implementation of blended learning in the formation of future priests.

1.1 Blended learning

Blended learning is often adopted to increase efficiency, decrease cost, or scale up the delivery of education to students. With the intensification of digital technology, especially the internet, computing skills are not the only necessary additions to the curriculum but also new modes of critical thinking and creative works. The integration of ICT in education has caused a shift from classical epistemology to a contemporary epistemology. It anchors on active learning, engagement, and shared creation of knowledge (Barsade and Gibson, 2007; Dede, 2008). In the new epistemology, knowledge is shared, stored, and manipulated to create new knowledge (del Moral et al., 2013; Dunaway, 2011; Janzen et al., 2012).

2 Related literature

Various studies have assessed different outcomes of blended learning, such as engagement, perception, self-reliance, responsibility, participation, and satisfaction (Hakala et al., 2011; Graham, 2013). This paper examines student achievement and motivation. These two crucial outcomes were chosen based on their relevance in the learning process and a lack of studies in the theology field. Thus, this part explores related literature concerning student achievement and motivation.

2.1 Student achievement

Achievement exposes the effectiveness of a learning experience and is assessed through student performance. Al-Mansour and Al-Shorman (2012) studied the effects of computer-assisted instruction on Saudi University students. Their findings indicated that integrating technology into traditional F2F teaching had a positive impact on students' achievement. Similarly, Mersal and Mersal (2014) found a positive correlation between student satisfaction and academic achievement. Banyen, Viriyavejakul, and Ratanaolarn (2016) reported that blended learning affected the learning achievement of Thai undergrad students by at least one variate in terms of learning and information literacy. Owston et al. (2013) studied students' achievement in a blended learning course and examined the relationship between student perception and their in-course achievement.

Other studies maintain that blended learning transforms students from being passive learners to ones that actively engage and perform better, thus leading to achievement (Al-Dosari, 2011; Hakala, Lanie, and Myllymäki, 2011; Kebualemang and Mogwe, 2017; Kintu et al., 2017; Wang et al., 2009).

On the other hand, some studies found that the introduction of blended learning did not affect student performance and achievement (Kwak et al., 2014; Delialioglu and Yildirim, 2008).

2.2 Student motivation

Crookes and Schmidt (1991) define motivation as "interest in and enthusiasm for the materials used in class; persistence with the learning task, as indicated by levels of attention or action for an extended duration; and levels of concentration and enjoyment" (p. 145). Peacock (1997), in turn, defines motivation as inspiring "interest, persistence, attention, and enjoyment in learners" (Hayes, 2009, p. 1). Both definitions place great value on interest and enjoyment. Vandergrift (2005), agreeing with the above definitions and assessment, stressed the importance of intrinsic (that which comes from a sense of competence, autonomy, and relatedness) and extrinsic (that which comes from the social environment in the form of a good job or promotion) motivations. Motivational frameworks promote intrinsic motivation by encouraging learner control while bolstering students' extrinsic motivation through appropriate assessment.

Blended learning increases self-motivation and directs students to be focused. It is difficult to measure student motivation because motivation includes curiosity, choice, agency, and self-efficacy. Heick (2017) presented the following list of motivation indicators: selection in assessment forms and criteria, a voice in content and material sources, collaboration with peers, self-directed interaction with the content, awareness of performance, frequent data-based adjustments, and data sources. Accordingly, Schober and Keller (2012) opined that the average learner motivation was high during specific periods but lower than expected on longer phases.

3 Methodology

3.1 Locale, respondents, and research design

The study was conducted at the Saint Peter's Pontifical Institute, Bangalore, India. Founded in 1778, the institution has followed the teacher-centred, traditional F2F teaching model. All students receive a single unified curriculum. A new elective course, a blended learning course on Communication Theology, was introduced to 21 or about half of the first-year theology students.

This study applied a combination of descriptive and quasi-experimental research design. The researcher used One group pretest-posttest design to assess students' learning achievement. The single experimental group used a blended learning lab rotation model for the Communication Theology course for one semester. Before the implementation, the teaching content was assessed, designed, and developed using the ADDIE (analysis, design, development, implementation, and evaluation) model. The students registered and logged in to Moodle, the learning management system (LMS) used in the course. The researcher created a Facebook group and encouraged the students to react, chat, comment, and share their ideas. The class was conducted once a week, and online activities were closely observed.

3.2 Data collection methods and instruments

During the course, quizzes, surveys, and assessments were conducted online, and a Google form was used to deploy the research instrument to collect data.

For the data collection at the end of the study, the students completed the online google form questionnaire containing three sections. The first section collected students' demographic/personal data to obtain the descriptive characteristics of the students. The second section evaluated students' achievement and motivation. Students' achievement and motivation were measured using five-point Likert-type questions coded from 1 (strongly disagree) to 5 (strongly agree) for each statement.

Student achievement, operationalised as perception, performance, and success, was evaluated using 12 statements with four statements for each parameter. The motivation was operationalised as interest, persistence, attention, and enjoyment. It was assessed using 12 statements with three statements for each parameter. The Cronbach's alpha coefficients for the 12 items measuring student achievement (.900) and the 12 items measuring motivation (.936) suggested that the items have relatively high internal consistency.

4 Results and discussion

4.1 Demographics

The study participants were 21 male seminarians pursuing theology at the St. Peter's Pontifical Institute of Theology. Most of the respondents were aged between 22–27 years old. They came from the three south Indian states that have different languages, cultures and customs. Thus, the instructional language was English.

4.2 Student achievement

As a significant outcome, student achievement was assessed in terms of perception, performance, and success. This major variable was evaluated using 12 statements, with four statements, each capturing the operationalisation for perception, performance, and success. *Perception* as a predictor of student achievement in blended learning refers to the attitudes, preferences, expectations, learning styles, actual situation, the fulfilment of learners' needs, and available facilities (Gyamfi and Gyaase, 2015; Huang, 2016). *On* the other hand, performance refers to students' academic performance (Alducin-Ochoa and Vázquez-Martínez, 2016), active engagement, and freedom to learn at their own pace or rhythm (Hakala et al., 2011). Finally, *success* refers to benefits achieved through technology and learning materials, self-confidence, and success in implementation (Spallino, 2015). In addition, a pretest-posttest was administered to determine if the blended learning model significantly contributed to students' knowledge gain, considered a related measure of their performance and, eventually, achievement.

In general, student achievement in the blended learning course on Communication Theology was rated very high, with an overall weighted mean of 4.56. Ratings for the 12 statements ranged from 4.43 (high) to 4.71 (very high) (Table 1). The three indicators of student achievement were given very high ratings (i.e., perception at 4.6, performance at 4.5, and success at 4.55). Each of the three variables is explained in detail in the following paragraphs.

Table 1. Assessing Student Achievement

Criteria	Mean	Description
Perception		
This course relieved me from writing notes during class.	4.67	Very high
I became an active learner with the use of computers for the Communication Theology course.	4.62	Very high
Various options in blended learning modality made my learning process very convenient and engaging.	4.57	Very high
The online quizzes and assignments adequately measured the learning achievement for each unit.	4.52	Very high
Overall mean for perception	4.60	Very high
Performance		
I have actively engaged and am emotionally involved in the whole course.	4.57	Very high

I was free to learn at my rhythm and gain maximum subject knowledge.	4.57	Very high
My final scores of blended learning in Communication Theology will be higher than other subjects.	4.48	High
The inclusion of ICT in the Communication Theology course made me perform better.	4.43	High
Overall mean for performance	4.51	Very high
Success		
The introduction of the blended learning modality in St. Peter's Pontifical Institute can be considered a big success.	4.71	Very high
My learning was very successful because of the availability of subject material in different forms at different places.	4.52	Very high
Studying Communication Theology using a blended learning modality is highly successful for me compared with other subjects using only the F2F model.	4.52	Very high
I can follow the other theology courses with the blended learning modality.	4.48	High
Overall mean for success	4.55	Very high
Overall weighted mean for student achievement	4.56	Very high

Note: 1.0–1.5 = very low; 1.51–2.50 = low; 2.51–3.50 = moderate; 3.51–4.5 = high; 4.51–5.00 = very high

4.2.1 Perception

How students perceive blended learning has a bearing on their class achievement. In this study, students perceived their blended learning experience favourably. They found that it relieved them from tedious note-taking, made them active learners, brought them into a learning process that is convenient and yet engaging, and made them appreciate the adequacy of the class requirements for measuring their learning achievement.

The following statement was rated the highest (4.67): *This course relieved me from writing notes during class*. Students were already heavily loaded with class notes and subject materials with 11 subjects every semester. In the blended learning class, they were relieved from taking notes. At the same time, they interacted well, asked questions, and clarified their doubts in the class. They also referred to the online content and studied them before writing their assignments.

The above result is supported by other studies on student perception of the blended learning environment (Kurt and Yildirim, 2018; López-Pérez et al., 2011; Money et al., 2016) that focused on students' opinions, satisfaction, tendencies, sense of engagement, and views of learning outcomes pertinent to blended learning. A general trend was observed that the students' favourable perception often leads to positive student achievement (Owston et al., 2013). Previous studies also noted that students perceived blended learning to improve learning and teaching and have a significant advantage over traditional learning (Dowling et al., 2003).

4.2.2 Performance

Students' evaluation of their learning performance had an overall high (4.5) mean rating. Their performance in the Communication Theology course was considered much better than their other subjects, which used only the traditional F2F classroom modality. The high rating was because they were actively engaged, emotionally involved, gained maximum content knowledge, and obtained higher scores in-class assignments and requirements.

The students' active engagement was evident when they were doing their assignments and participating in learning activities. They recognised the importance of this new modality and were involved individually as well as in the group. They performed well to gain knowledge of the subject and shared their findings with others in online chats. Other studies also found that blended learning is significantly associated with more outstanding performance than the traditional F2F model. Bazelais and Doleck (2018) suggested that the blended learning approach leads to more conceptual change and higher performance. Similarly, Vo et al. (2017) concluded that blended learning was significantly associated with better performance.

4.2.3 Success

The last component variable of achievement pertained to success. The statement on the introduction of blended learning considered a success was rated the highest (4.71) by the students.

Factors that contributed to the perceived success of the blended learning course included the availability of learning materials in different forms and at different places and the preparedness to take other subjects in theology using blended learning acquired by the students. Traditional F2F teaching has the monopoly of learning content with the teacher or in the printed notes, and students are limited to the same space and time. The students expressed preparedness through their desire to follow even other courses with this new modality.

Several studies conducted on the use of blended learning in universities confirmed that blended learning was more effective than the F2F modality in terms of better student grades, higher passing rates, student preparedness, ability to access the learning content, maximising blended learning advantages, and improvement in student success and satisfaction (Akkoyunlu and Soylu, 2008; Boyle et al., 2003; Dziuban et al., 2018; Mersal and Mersal, 2014; Mustapa et al., 2015; Vernadakis et al., 2012).

4.3 Pretest-posttest design

Another way the student achievement was evaluated in this study was through the one-group pretest-posttest design, which involves measuring the group's score before and after the treatment (Table 2). The pretest conducted just before implementing the blended learning course could be considered a part of formative evaluation (Branch, 2009) and the posttest a part of the summative evaluation (Linh and Suppasetseree, 2016). Here, the students were given a test on their knowledge of the Communication Theology subject before studying it. Then, they went through blended learning during the semester, and at the end of the semester, they retook the same test.

Table 2. The one-group pretest-posttest design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2

The students had a pretest (O_1) to evaluate their subject knowledge at the beginning of the course. After administering blended learning for one semester, the students took the posttest (O_2) to assess their knowledge gain. To determine if the difference in learning gained is significant, the Wilcoxon Signed-Rank test was used. Their mean scores before and after the blended learning experience were compared to see if blended learning as an intervention made a significant difference in their knowledge gain.

The posttest mean score achieved by the group was indeed significantly higher (p=.000) at a 5% level of significance (Table 3). This means that the posttest mean score achieved by the group was indeed significantly higher than their pretest mean score. Students' posttest mean scores before and after the blended learning treatment were compared. On average, students scored better after (M=19.10) than before blended learning (M =13.24). A Wilcoxon signed-rank test indicated that posttest ranks were statistically significantly higher than pretest ranks Z=−4.06, p<.000. It further implies that blended learning has indeed contributed to the marked difference in their knowledge gain.

Table 3. Results of the Wilcoxon Signed-Rank test

Test	n	$\overline{X}$	SD	Wilcoxon Signed-Rank Test		
				Mean Rank	*Z* value	*p*-Value
Pretest	21	13.24	2.02	11.0	-4.06	.000
Posttest	21	19.10	0.62			

The statistical test showed that the knowledge gained by students with the use of the lab rotation model of blended learning was significant. This implies that blended learning can enhance learning achievement, especially in the teaching of Communication Theology. The course grade is one of the major indicators of student achievement (Galy et al., 2011), and the pre- and posttest scores clearly showed students' achievement.

4.4 Motivation

Crookes and Schmidt (1991) defined motivation as "interest in and enthusiasm for the materials used in class; persistence with the learning task, as indicated by levels of attention or action for an extended duration; and levels of concentration and enjoyment" (p. 498). There are two types of motivation: intrinsic and extrinsic. Intrinsic motivation is the dominant type in blended learning. The intrinsically motivated students finish the tasks and show better performance than the extrinsically motivated ones (Law et al., 2019). Motivation in this study was assessed using interest, persistence, attention, and enjoyment as the more specific parameters (Peacock, 1997).

As an outcome of blended learning, student motivation was evaluated using 12 statements, with three statements assigned for each of the four specific parameters. The result indicated an aggregated mean of 4.52 or very high student motivation (Table 4). All 12 statements were rated from high (4.24) to very high (4.67).

Table 4. Assessing student motivation

Criteria	**Mean**	**Description**
Interest		
I was eager to choose the blended learning Communication Theology course as an elective course.	4.67	Very high
The relevant subject material made available in different places contributed to my better learning.	4.57	Very high
Adopting ICT to teach Communication Theology increased my interest to learn.	4.57	Very high
Overall mean for interest	4.60	Very high
Persistence		
The online content placed in Moodle is relevant to my interest and motivated me to learn.	4.52	Very high
The inclusion of different methods (F2F and online activities) made me persistent in the learning process.	4.52	Very high
I exerted effort learning on Moodle and learning at my rhythm.	4.48	High
Overall mean for persistence	4.51	Very high

Attention		
My IT interest was helpful in learning Communication Theology.	4.52	Very high
The different evaluations made me focused and encouraged me to perform better	4.57	Very high
ICT integration in Com. Theology increased my attention and curiosity to learn.	4.24	High
Overall mean for attention	4.44	High
Enjoyment		
Blended learning on the Communication Theology course was less tedious, increased self-motivation and directed me to be more focused.	4.38	High
Blended learning modality makes the learning of a serious subject like Communication Theology lighter.	4.48	High
I enjoyed the Communication Theology course in blended learning mode as I can own and control my learning process.	4.67	Very high
Overall mean for enjoyment	4.51	Very high
Overall weighted mean for motivation	4.52	Very high

Note: 1.0–1.5 = very low; 1.51–2.50 = low; 2.51–3.50 = moderate; 3.51–4.5 = high; 4.51–5.00 = very high

4.4.1 Interest

Motivation and learning are interrelated. Motivation to learn or interest is essential to do learning activities because, without motivation, students will not do the learning activities (Islam et al., 2018). Integrating ICT and the availability of content in different forms and places must have increased the students' interest in blended learning.

The overall mean rating for interest was very high (4.6). This may be further attributed to the newness of using online or mediated learning as part of the students' learning setting. As with anything new, the tendency is to be more curious or interested to learn a new thing or skill. Especially among seminarians, the unique experience also tended to stimulate their minds, thus creating more interest. Having gained some degree of freedom from their usual rigid schedule, the students may have pushed themselves past their comfort zone to discover new things, not only about the skill or subject but also about themselves. This is supported by Cathrine's (2019) contention that, often, learning a new skill or practice becomes a positive distraction from the routine of daily lives.

4.4.2 Persistence

Motivation energises, directs, and sustains behaviours allowing students to engage and guide themselves in a particular direction and continue exploring them (Law et al., 2019). Learner attitudes in blended learning will result in effectiveness and shape behavioural intentions, which will lead to persistence in the learning environment (Kintu, Zhu, and Kagambe, 2017).

Persistence, as the second variable under motivation, obtained a high mean rating (4.5). Blended learning resulting in better persistence, may be explained by the increased responsibility given to students over learning as they tackle activities outside of the classroom at their own time. While they may have gained some degree of freedom, this calls for some degree of responsibility, which challenges them to be more persistent to attend and pursue the tasks and exercises assigned to them by the teacher outside of class hours.

4.4.3 Attention

Since blended learning combines both online and traditional modes to improve and make classes attentive and engage the students, it certainly increases involvement and student motivation (Sari et al., 2018). The variety of teaching materials and modes in blended learning could have contributed to building up the students' attentiveness. Unlike other classes of the institute, blended learning used PowerPoint presentations, YouTube videos, audio, and class activities, such as discussions and quizzes.

The overall mean for attention was high (4.4). As motivating factors for attention, students' interest (4.52) and variety in evaluation (4.57) were rated high. The assessment of the integration of ICT as a factor for increasing attention and curiosity was also ranked high (4.24).

Moreover, the personalised aspect of learning inevitably requires attention from the students; otherwise, their academic performance suffers. For example, when students were asked to write the first and second assignments, they were given the opportunity for personal reflection. Moreover, the second assignment, which was a reflection on Communication Theology, demanded that students think individually and present their reflection online.

4.4.4 Enjoyment

Enjoyment obtained an overall mean rating of 4.51 or very high. The choices and opportunities in blended learning make it more enjoyable. Blended learning offers the choice of online and offline materials, and at the same time, opportunities for interaction. As Rossett and Frazee (2006) found, it successfully bridges the classroom with the workplace or learning places.

Enjoyment, as intrinsic motivation, engages the learners and makes them active partakers in the process of learning (Ibrahim and Nat, 2019). The students enjoyed the courses and considered blended learning as an excellent way to teach and learn theology.

5 Conclusion

To conclude, student achievement in a blended learning environment is a reflection of student efforts. The students who showed higher interest and put in more effort than their peers have, in turn, achieved better results (Tucker-Drob and Briley, 2012). The students' high scores throughout the course and their final scores proved that the students worked hard to achieve the course objectives. Thus, student achievement in this study demonstrated that blended learning is an effective model built on the minimisation of the negative aspects of online and F2F environments and the convergence of the advantages of both approaches (Bonk and Graham, 2012; Melton et al., 2009).

In this study, blended learning effectively combined and integrated the beneficial aspects of F2F and online instructions. The study showed increased student achievement and motivation among the students after the implementation of the blended learning modality. Student motivation was rated very high (4.56), facilitating student achievement in the course. This was further validated by the one group pretest-posttest that showed a considerable increase in the posttest scores. Similarly, motivation was rated very high (4.52). The respondents recommended that the implementation of blended learning be done for other courses too, and accentuated the importance of lifelong technology-aided learning.

Based on the results on the two outcomes of blended learning, achievement and motivation, the following recommendations were made. Other outcomes like student satisfaction, participation and responsibility can be studied, and their interrelationship with these two can be further analysed. The same study can be undertaken for the other subjects with a different model of blended learning. The same research can be done in another institute and compared with this study for improvement and modification. The faculty and student readiness for integration of blended learning can be further explored. The use of different tools and technologies of both online and offline teaching for theology subjects can be investigated.

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The Robots Will Rule: Improving Coursework Marking and Feedback Through an Automated System

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Abstract

Purpose – Delivering high-quality, timely and formative feedback for students' code-based coursework submissions is a problem faced by computer science (CS) educators. Automated feedback systems (AFSs) can provide immediate feedback on students' work, without requiring them to be physically present in the classroom — an increasingly important consideration for education in the context of COVID-19 lockdowns. There are concerns, however, surrounding the quality of the feedback provided by existing AFSs, with many systems simply presenting a score, a binary classification (pass/fail), or a basic error identification ('The program could not run.'). Such feedback, with little guidance on how to rectify any problems, raises doubts about whether these systems can stimulate deep engagement with the related knowledge or learning activities. This paper presents experience in developing and deploying a new AFS that attempts to address the current deficiencies identified.

Design/methodology/approach – We developed an AFS to mark and provide feedback to 160 CS students studying an introductory Databases class. The experience of designing, deploying, and evolving the AFS is examined through reflective practice, and focus-group (involving peer teachers) analysis. The student experience of the AFS is explored through formal university-level feedback systems, and a follow-up survey and interviews.

Findings – In contrast to most introductory-level coursework feedback and marking, which typically generate significant student reaction and requests for change, our AFS deployment resulted in zero grade-challenges. There were also no identified marking errors, or suggested inconsistencies or unfairness. Student feedback on the AFS was universally positive, with comments indicating an AFS-related increase in student motivation. Interesting perspectives that emerged from our reflections and analysis included the issues of how much impact our own software engineering training and approach to building and deploying the AFS had on this success.

Originality/value/implications – Our successful experience of building and using an AFS will be of interest to the entire teaching community, not just CS/SE educators. The associated increases in marking and feedback reproducibility, accountability, and automation represent an important advance in AFS technology. In collaboration with our students, we are currently evolving the AFS into an autonomous learning object that they will be able to use independently of regular classes. Eventually, we hope to release the AFS to a wider audience as an open educational resource (OER).

Keywords: automated feedback, student engagement, technology-enabled student advising, open education resource

1 Introduction

The impact of the global COVID-19 pandemic caught a number of higher education (HE) institutions (HEIs) unprepared, requiring them to rapidly rethink and revise their approach to teaching and learning (T&L) practices, particularly regarding assessment and the provision of feedback to students (Gill et al., 2020). This is especially true for Computer Science (CS) educators, who rely on in-person interactions during practical laboratory sessions to provide guidance to novice programmers who embark on the challenging adventure of learning to program.

Programming is a complex activity, requiring learners to abide by strict syntax rules, decipher complex (and often unintuitive) error reports, and develop correct logical statements and structures to solve a given problem or task (Jenkins, 2002). Learning to program is a practice-led activity (Tan et al, 2009). Students cannot learn to program by reading a textbook or attending lectures, alone. Practice is a critical factor in the acquisition of programming skills (Robins et al., 2003). Laboratory sessions are not only an opportunity for CS students to practice their programming, also allow them to obtain immediate, contextual feedback on their code from teaching staff. Often, this feedback is delivered in a multimodal form, including spoken explanations, referencing to code on-screen through finger pointing and sometimes the direct editing of the student's code to demonstrate the necessary remedial action. The provision of feedback is known to be a critical factor in reinforcing student's learning (Shute, 2008). It is also the source of great dissatisfaction amongst students, who are consistently less satisfied with feedback than with any other feature of their courses (Nicol et al., 2014). In the aftermath of COVID-19 the increasingly distributed and hybrid nature of HE learning environments will challenge traditional forms of feedback provision. Alternative approaches are therefore required to address this challenge.

Many CS educators have explored the use of Automated Feedback Systems (AFSs) for the provision of feedback to novice programmers (Towey & Zhang, 2017; Singh et al., 2013; Odekirk-Hash & Zachary, 2001; Ala-Mutka, 2005). AFSs have many favorable properties — including timeliness and consistency — and can be an always-available resource, allowing students to receive formative feedback outside of timetabled sessions. AFSs are not a silver bullet, however, as there are many shortcomings associated with their use. Students often remark that AFS feedback is not sufficiently detailed or specific, often providing only a "pass or fail" indicator of performance, with little or no guidance to novice programmers about how to proceed to improve or fix their code (Keuning et al., 2016). CS educators have also highlighted issues, including the adaptability of these systems for use in particular assessments, which often required additional programming to overcome technical constraints imposed by the AFS itself (Keuning et al., 2016).

In this paper we explore an alternative approach to the development and deployment of an AFS. Specifically, our approach only generates and builds the feedback that students will receive *after* they have submitted their solutions. This is in contrast to conventional AFS approaches, where the marking logic and feedback are typically prepared in parallel with the task specification — before students submit their solutions. Similarly, in our application, students do not interact directly with the AFS, in-fact, they may not even be aware of the existence of the AFS. Students complete their assignments *as usual*, without needing to conform to the technical or logistical constraints imposed by the AFS, thus preserving the ecology in which they write their code. Additionally, we explore the impact of applying standard software methodologies, specifically Agile and Test-Driven Development in an educational context. We posit that the application of these methodologies may improve the quality of feedback provision in the context of developing programming skills.

2 Context

The University of Nottingham delivers the same degree content across all of its campuses, including at the University of Nottingham Ningbo China (UNNC), where the undergraduate degree programmes related to CS are fully accredited by relevant professional organisations. During the first year of the CS programme, a strong focus is placed on developing students' programming skills. The "Databases and Interfaces" (DBI) class is one of the programming-based classes that all CS undergraduates complete. DBI provides students with a general introduction to the theory and practice of database systems, with students learning to create and interact with databases using a structured query language, SQL (Eisenberg & Melton, 1999). Additionally, students learn to design and implement graphical user interfaces (GUIs) in a web-based context, interacting with standard web technologies such as HTML (Hickson & Hyatt, 2011) and CSS (Bos et al., 2005). The DBI class has run, under various names and formations, for over a decade at UNNC and is a well-established part of the CS programme.

In the aftermath of the COVID-19 pandemic, the DBI teachers revised and adapted the class for a hybrid delivery, which included providing for approximately 30 remote-learning students and 130 in-person students. Prior to COVID-19, DBI relied heavily on a centralized technical infrastructure, situated on the university campus. This infrastructure provided students with access to an Apache[1] webserver and a MariaDB[2] database server, allowing DBI students to complete weekly laboratory tasks and coursework. This infrastructure worked well with on-campus students, providing a reliable and convenient resource. Other classes within the school also used this infrastructure. However, a number of off-campus students, especially those outside of Mainland China, faced great difficulties obtaining a reliable connection to the campus network. Some of the technical limitations were insurmountable, introducing a significant challenge to the university and great frustration to students. The class instructors decided, for 2020-2021, to transition to a local technical infrastructure, meaning the software required for the participating in DBI would be run directly on the students' personal computing devices. In doing so, the instructors were keen to use freely available and lightweight (small memory and hard-disk requirements) software solutions, being aware that some students were working on constrained computing devices.

SQLite[3] was used as the database server software. SQLite is a small, fast, self-contained, high-reliability, full-featured, SQL database engine. SQLite is freely

[1] Apache Web Server - https://httpd.apache.org/
[2] MariaDB Database Server- https://mariadb.org/
[3] SQLite Database Engine - https://www.sqlite.org/index.html

available on all major operating systems and is a small download (<1MB), which was an important consideration for students with poor network connectivity. Apache was replaced by Flask[4], a lightweight web framework written in Python[5]. Flask provides functionality to serve static (HTML, CSS) and dynamic webpages using data stored in SQLite (and other) databases. Again, Flask was chosen for its lightweight installation process and its availability on all major operating systems.

The first week of laboratory sessions were dedicated to ensuring that students' machines were correctly configured, and capable of using the software. This process was relatively smooth, with few technical challenges. Once the set-up was confirmed, we began to specify and develop the coursework around these software technologies.

DBI is assessed through both a written examination and coursework. The coursework is split into two activities, with Coursework-1 consisting of multiple quizzes assessing knowledge and understanding, while Coursework-2 (CW2) focusses on application. CW2 will be the focus of the remaining sections. For CW2, students were presented with a fictional, but realistic, scenario, in which they were to complete a partially-implemented inventory tracking system. Students were given a partial codebase and an SQLite database, upon which their solutions would be developed. The database was structurally complete, with all the necessary tables in place to support the application's data requirements. The data itself were incomplete, an issue students would be required to address (Task 1, below). All students received an identical initial (partially-implemented) codebase, to which they were expected to add the functionality specified below. The coursework involved standard web-technologies that students had become familiar with through the DBI course (HTML, CSS, SQL and Python). Students were given approximately three-weeks to complete CW2, which contributed 25% to their overall DBI mark. In addition to a task description, students were also provided with a detailed marking scheme. Students were required to complete the following three tasks for CW2:

Task 1. Database Initialization – Students were provided with inventory data stored in a Comma Separated (CSV) file. Task 1 required students to implement a code-based procedure capable of initializing the database using the data stored in the CSV file. This required students to parse the contents of the CSV and specify the necessary SQL to insert the data into the tables provided with the coursework.

Task 2. Read from the Database – The partially implemented codebase had the necessary information to display the details of the inventory, through a web-based user interface. Task 2 required students to develop the SQL necessary to extract and collate the details of inventory items, for display in the web application; and to integrate the code with the existing code base.

Task 3. Insert into the Database – Students were required to obtain input from users, through a web-based form, and insert it as a new item in the inventory collection. Task 3 also required students to perform the necessary validation and

[4] Flask Micro Web-Framework - https://flask.palletsprojects.com/en/1.1.x/
[5] The Python Programming Language - https://www.python.org/

checking of the user provided input to ensure it met the specified data specifications.

3 Automated Feedback Systems

Students' solutions were submitted through Moodle[6], the learning management system used at UNNC. Solutions were then downloaded by the coursework marker and prepared, through an automated process, for use with the AFS. Preparation consisted of renaming submissions according to student's ID and separating each task's solution files into sub-directories, isolating individual components of the assessment process. It was decided that students would not interact directly with the AFS: Instead, they would develop their solutions in a typical development environment, unconstrained by any technical or operational limitations of the AFS (Keuning et al., 2016). This approach had the benefit of preserving the ecology of the task, mirroring the development students will encounter when completing industrial work. The feedback itself would be delivered in a feedback-file on Moodle.

Once preparation was complete, the CW2 marker then initiated the first stage of the marking procedure. The overall process was divided into two phases: 1) running the application; and 2) parsing the output, allocating a mark and generating the feedback. The two phases were separated to avoid potential interference between student solutions and the operation of the AFS. Security was a practical concern for the first phase, something the marker considered carefully. All student solutions were run in a sandboxed Docker[7] container, a lightweight virtualization technology that allows code to run in consistent, isolated operating environment. Changes to a container's files or settings by an application are discarded once the container is powered down. This approach was taken to ensure that the environment where students' solutions were run was consistent; it also follows best security practices regarding the running of untrusted code (Špaček et al., 2015). The output of each student solution was captured, and stored to disk, ready for stage two, where the actual assessment was performed. The orchestration of this process was entirely automated.

Stage two saw the output of the previous stage being analysed according to the marking criteria. It was here that the CW2 marker began to implement the marking criteria, in code. This approach differs from the conventional, with the majority of existing AFSs being used as the framework around which assessment tasks are built. Typically, the marking logic used in an AFS will be developed simultaneously with the specification of the particular coursework. In this case, however, the AFS was developed *after* students had submitted their solutions. By following this approach, the CW2 marker had a corpus of *real solutions* upon which feedback appearing in the solutions. In addition to providing specific, tailored feedback, this approach enables a high level of adaptability, something that is a limiting factor in many existing AFSs (Keuning et al., 2016).

[6] Moodle learning management system - https://moodle.org/
[7] Docker Containerization Platform - https://www.docker.com/

When marking, the CW2 marker first wrote a test to identify the correctness of a particular solution. Correct solutions are straightforward to mark, as they meet a predictable, pre-specified criterion: The marker can check whether or not the criterion was correctly realized in the student solution, and allocate a mark, accordingly. However, as is common with developing programmatic solutions, there may be multiple correct solutions that are equally valid. Certain solutions may, however, possess properties that are more desirable — for example: faster execution, lower memory utilization, or a solution that follows best practices. Therefore, in addition to identifying the correctness of a given solution, where appropriate, the feedback was tailored according to the particular implementation approach taken.

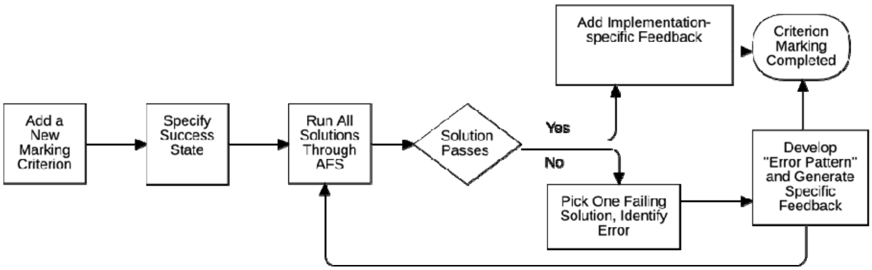

Fig. 1. The implementation workflow for a single marking criterion within the AFS

Having identified, marked and developed feedback for correct solutions, the CW2 marker then looked at solutions that failed to meet the specified marking. This process began with the developer performing a manual inspection of one of the incorrect solutions. Having identified the particular error, an "error pattern" was developed (in code) to identify the particular fault, and added to the AFS. Specific feedback was also generated to highlight the error and provide advice on how to attempt to rectify it. The AFS was then run again, on all solutions, to identify others that shared the same "error pattern". This process was repeated until all solutions were processed. This approach borrows from the software development methodology, Test-driven development (TDD) (Janzen & Saiedian, 2005). TDD requires a developer to first write a test for a particular unit of functionality, before writing the code to fulfill that functionality. The test can then be used to validate that implementation of the functionality meets the functional requirements specified in the test. However, in this application of TDD, the CW2 marker specified tests to interrogate the correctness of student solutions and provide feedback accordingly. Students' solutions were therefore viewed as the 'units' under test. Test coverage is a metric used in TDD to measures the amount of testing performed by a set of tests. Test coverage, in the context of this application, was the coverage of feedback provided to the set of student solutions. We required 100% coverage, meaning that every student submission had a mark and at least one item of feedback for each marking criterion.

The DBI CW2 marking was successfully completed, and submitted on time. Students received a detailed report containing their individual feedback and score. In contrast to most introductory-level coursework feedback and marking, which typically generate significant student reaction and change requests, our AFS deployment resulted in no grade-challenges. There were also no identified marking errors, or suggested inconsistencies or unfairness. Student feedback on the AFS was universally positive, with comments indicating an AFS-related increase in student motivation.

Task 1 [4.0/5]

Task 1 was marked using the following procedure:

- The original `iMusic.db` database (containing 50 tracks) was copied into the working directory, which also included `TracksToAdd.tsv` and the `TSV_Import.py` that you submitted.
- The command `python TSV_Import.py` was executed in the working directory containing your solution.
- An automated process was used to identify differences between the `iMusic.db` database generated by your solution (`TSV_Import.py`) and the validated (correct) version. **Note** - TrackId was ignored when performing this comparison.

ID	Requirement	Feedback	Marks
1A	Your solution executes, without error or modification, using one of the commands `python TSV_Import.py` or `python3 TSV_Import.py`	The submitted solution ran without modification or error.	1/1
1B	Your solution correctly parses the TSV using the `csv` module.	The solution makes correct use of the CSV library.	1/1
1C	Your solution inserts all entries specified in the TSV file correctly into the database using the `sqlite3` module.	A good solution, which correctly handles Tab and UTF-8 characters and does not insert the header in the Track table. However your solution not handle quotes characters correctly.	1.5/2
1D	Your solution should have suitable checks to ensure that the operation completed with raising an `Exception`.	A single try/catch statement is used to capture exceptions across the entire solution. Be warned - this is generally considered bad practice, specific exceptions should be handled.	0.5/1

Fig. 2. Example of AFS-generated feedback for a single task

We suggest that our AFS addressed a category of errors that are commonly encountered when marking a large number of student assignments requiring detailed technical analysis. Specifically, our AFS promotes:

- **Consistency** – The marking is deterministic: The feedback and grading of coursework is the same for all submissions that follow a particular implementation strategy. Consistency here refers to both the provision of marks and feedback.
- **Correctness** - Simply automating the process of marking does not ensure the correctness of the output. However, when combined with the incremental and iterative development methodology detailed here, a number of the shortcomings typically associated with AFSs were successfully avoided.
- **Tailored Feedback** – Feedback provided to students is specific, relevant, and detailed; and not simply determined on a pass or fail basis.

4 Discussion

Good software engineering practice includes performing regular retrospectives, reflecting and learning from experiences (Dybå et al., 2014). The innovation described in this paper was in response to a growing number of first-year CS students participating in the DBI class. The increase in the number of students was predictable, the impact of COVID-19, however, was less so. It is hoped that the introduction of an AFS has helped to address both challenges. The introduction of the AFS in the 2020-2021 run of DBI helped address the issue of a larger class size, with coursework feedback scores and feedback being returned, on-time, with only a single marker being involved in the marking process. There was a significant initial time investment required in developing the AFS, crucially however, the time required was comparable to the time required to manually mark 160 student submissions. The net benefit of consistent and correct marking, and detailed and tailored individual feedback, as well as a reusable education resource, struck a positive tone with the DBI teachers. Equally, future runs of DBI will benefit from the AFS. The system will still require tailoring for the specific task students are expected to complete, but much of the current infrastructure is reusable.

Going forward, it is hoped that the AFS can be repurposed as an Open Education Resource (OER) (Towey et al., 2019). This would provide an effective solution for the DBI instructors, who benefit from current students receiving high-quality, consistent and timely feedback on their coursework. Additionally, in the form of an OER, students would be able to interact with and obtain formative feedback on solution attempts – without explicitly interacting with the instructors. The AFS OER could also be deployed during the laboratory sessions, reducing the demands on staff, allowing them to provide more detailed and insightful feedback to students encountering situations or questions that are not addressed by the AFS.

The repurposing of the AFS as an OER will address another issue that students raise in their evaluation of DBI: the amount of content delivered in the class. Students report being overwhelmed by the number of technologies introduced. This an unfortunate (but necessary) reality of web-based development, which is dependent on the interaction of several technologies, that, in isolation, serve little purpose. The availability of an OER would allow students to prepare for DBI outside of timetabled hours, when feedback from the teacher is not available. Similarly, the analytics available to the teacher, from students' interactions with the AFS, may help highlight to the teacher the particular problem areas that students are experiencing.

Finally, this work also exemplifies the increasingly prevalent role automation is playing in HE (Beck et al., 1996; Andriessen & Sandberg, 1999). As we saw, removing the human from the process of manually marking CW2 led to more consistent and uniform feedback, while preserving specific, tailored feedback to individual students. Although in our AFS, there remains a human "in the loop" who is responsible for specifying the "error patterns" and generating responses, this may be viewed as a bootstrapping process: We could argue that the data necessary for a fully autonomous, generalizable AFS is being gathered to support a future, self-sustaining artificial intelligence (AI) AFS.

5 Conclusion

The provision of feedback is an important, but challenging, aspect of developing programming skills in novice programmers. The work presented in this paper outlines a novel approach in the specification and development of an AFS. Additionally, this work demonstrates the successful application of two Software Engineering methodologies in a T&L context, specifically in generating summative feedback of students' programming solutions. The current AFS will continue to be used, and there are plans to evolve it, to better support student learning in future DBI coursework and laboratory sessions. Further, we are planning to repurpose the AFS as an OER, and make it available to the community, enabling novice programmers to develop their programming skills independent of classes or institution.

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Understanding the Cybersickness Effects of Using Virtual Reality-based Classrooms for Undergraduate Students: A Preliminary Study

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Abstract

Purpose – Virtual reality (VR) technologies have expanded their domain of application towards education, offering various pedagogical advantages such as an immersive environment, teaching innovation, and in-depth user engagement by allowing the students to experience real-life scenarios of the taught subject through virtual simulations. Motion sickness, as one of the long-standing key challenges of VR utilization, even in gaming, often becomes a barrier for VR users to fully engage with the content developed in the virtual world. Thus, this work presents a preliminary study on understanding the symptoms of motion sickness — which will be referred to later as 'cybersickness' — in the teaching and learning (T&L) context.

Design/methodology/approach – A VR-based virtual classroom (V-Room) was developed and tested, in which 60 undergraduate students at the University of Nottingham Ningbo China (UNNC) participated. In this study, the students were equipped with the same VR headset and had the same V-Room environment. Data were collected through a two-step questionnaire, using both qualitative and quantitative measures, that was distributed to the participants before and after the study session. The severity of cybersickness was categorized into low-impact, medium-impact, and high-impact symptoms, alongside an overall comfort level experienced in the V-Room. Using the ANOVA F-test statistical approach, the data were analysed based on the following two research questions: (1) Has gender an influence on the presence of cybersickness symptoms?; and (ii) Does students' academic background (i.e. natural sciences and social science) also affect their experience in using VR for learning?

Findings – The results demonstrated that approximately 47% of the participants had experienced cybersickness during the V-Room experiential journey, of whom 64% were females. With a confidence level of 95% (α=5%), the p-value obtained for the respective gender and study discipline categories against the cybersickness symptoms were all smaller than 0.05, indicating that there was a significant difference between the two compared variables. Likewise, the F-statistical value was larger than the F-critical value, showing that both gender and study discipline have a considerable impact on the cybersickness. Moreover, it is worth highlighting that the top three factors that caused the cybersickness were the speed of the virtual movement, the perspective angle, and the visual properties of the virtual environment.

Originality/value/implications – It is hoped that the results of this study provide valuable pointers for future VR-based virtual classroom developers to minimize the cybersickness symptoms in the higher education T&L context that would enable an effective learning environment for the students.

Keywords: V-Room, virtual reality, cybersickness, motion sickness, teaching and learning, education technology

1 Introduction

Motion sickness (MS) is a common syndrome that typically occurs due to the mismatch between perceived and expected motion (Takov & Tadi, 2021). Nooij et al. (2021) believed that MS could also be induced by the belief that motion is happening, although in reality, no motion is detected. MS usually manifests differently on different individuals, although many reported overlapping symptoms such as nausea, headache, stomach awareness, disorientation, vomiting and more (Golding, 2016; Takov & Tadi, 2021). According to Lackner (2014), MS can be instigated by three types of motion: physical, visual, and virtual.

In recent years, visual and virtual motion sickness (collectively designated as visually induced motion sickness or VIMS) are increasingly reported along with the rapid development of visual and virtual technologies, such as the 3D motion picture in cinemas (Flanagan et al., 2004; Solimini, 2013) and virtual reality (VR) technologies (Chang et al., 2020).

Following the rising use of VR technologies in daily life and the emergence of affordable low-cost VR equipment, VR cybersickness continues to be one of the most common side effects of using VR. There is thus an increasing need to better understand the effects and impacts of motion sickness in VR. Thus, it is important to first understand the relationship of different factors that potentially cause or trigger the occurrence VR cybersickness.

1.1 Motion Sickness

Virtual Reality motion sickness (VRMS), also known as cybersickness or virtual reality sickness, is a subset of MS that is often linked to the use or immersion in VR environments (Chang et al., 2020; Yildirim, 2019). People who experienced VRMS typically reported similar symptoms compared to that of traditional MS (Chang et al., 2020; McCauley & Sharkey, 1992; Yildirim, 2019).

One notable study by Mazloumi Gavgani et al. (2018) has tried to compare between VRMS and "classical" MS. The study had concluded that "cybersickness and classic motion sickness are clinically identical, at least in their advanced stages" (Gavgani et al., 2018, p.1679) based on the similarity of symptoms and autonomic changes between VRMS and traditional MS in the same group of volunteer participants.

The occurrence of VRMS could be explained through the sensory conflict theory, i.e., the mismatch between visual stimuli and the vestibular senses (Ng et al., 2020). When VR users are immersed in virtual environments, what they observe are created virtually and usually do not correspond to their physical situation or position, thus causing different feedbacks between what the eyes see and what they experienced physiologically.

1.2 VR Cybersickness (VRC) in Various Applications

As VR technologies are being continuously developed and studied, its application amongst a plethora of discipline has also increased, especially in the field of higher education, video games, medicine/healthcare, and the social sciences, such as history (Cipresso et al., 2018; Radianti et al., 2020; Yildirim, 2019).

In the context of VRC presence in the field of healthcare, Servotte et al. (2020) conducted a study specifically amongst a group of predominantly undergraduate healthcare students and postgraduates with no special trainings. The study used a specially made VR simulation that was developed following medical emergencies scenarios that were designed by healthcare professionals. Servotte et al. found that a high sense of presence during VR immersion is associated with low level of cybersickness, albeit discomfort caused by VR was still observed. To add on, a study by Taylor & Layland (2019) tried to investigate different forms of virtual simulations and its prevalence in inducing VRC in the context of healthcare. Amongst the simulations were “360-degree video, manikin, standardised patient, and video case study” (Taylor & Layland, 2019, p.171). It was found that participants are not more likely to get MS from VR-based simulation than from other type of simulations, thus justifying the use of VR in healthcare.

The presence of VRC in video games, another field involves VR technologies and VRC, has also been widely investigated. Most video games incorporate elements of digital graphics, storytelling, and user immersion to deliver a compelling narrative and gameplay that draw players to play it. VR video games, which offer fully-immersive virtual environments, are of no exception to cause cybersickness. However, Weech et al. (2020) has interestingly found that VRC is negatively correlated to the sense of presence in VR games. To put it simply, an enriched narrative/story allows for players to be more immersed and present in the game, which in turn reduces the effect of cybersickness.

Having looked at how common the MS and VRC symptoms appeared in the use of digital to virtual environment in various applications, the current work focuses on a specific implementation in the context of Higher Education to observe students reaction towards this, *i.e.,* when a VR-based classroom is used in their teaching and learning conduct. Hence, a pilot study was conducted to investigate whether the cybersickness effects are linked to the utilisation of VR devices, and if so, the symptoms that are associated with the VRC will also be identified. In this paper, the presence of VRC symptoms in the use of a VR-based classroom, and how these symptoms are related to the students’ background will be identified. Causes of the VRC symptoms, when present, will also be studied according to the students’ receptive level of severity and commonness during the VR experience of the virtual classroom. The following sections will present and analyse the data obtained from the pilot study survey, starting from how the study was designed and conducted (Section

2), statistical process of the survey data analysis (Section 3), and what can be concluded from the results including future work of this study (Section 4).

2 Methodologies

This V-Room pilot study aims to provide a preliminary understanding of the VRC effect of using VR-based classroom in the teaching and learning area for undergraduate students. The study has been reviewed and approved by the University Research Ethics Subcommittee according to the ethical review processes of UNNC. These processes, as shown in Figure 1, are governed by the University's Code of Research Conduct and Research Ethics.

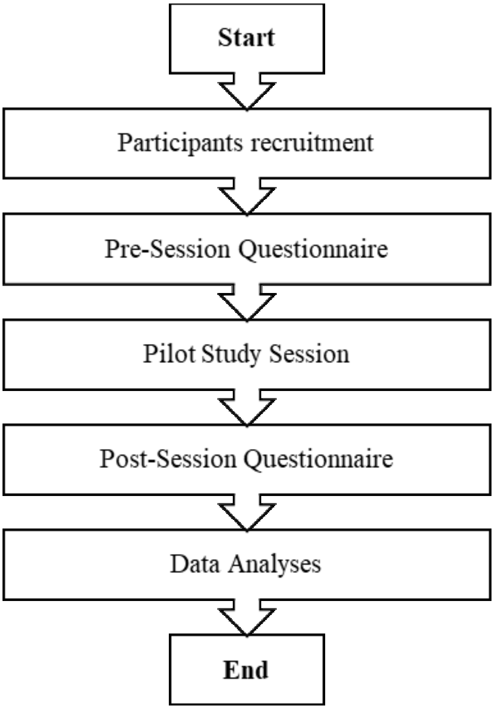

Fig. 1. Flowchart of the V-Room research methodology

2.1 Participants

A total of 60 healthy participants from various study disciplines were selected to participate in the study following a volunteer sampling method. Amongst these participants, 33 came from study disciplines of the Social Sciences, and 27 from the Natural Sciences. Table 1 below summarises the demography of the participants based on their gender and study disciplines. It was worthwhile noting that from this pool of participants, 68.3% of the participants have had previous experience with the use of VR technologies and equipment.

Table 1. Participants Demography (Disciplines & Gender)

Study Disciplines	Male	Female	Total *n*
Natural Sciences	14	13	**27**
Social Sciences	13	20	**33**
Total *n*	**27**	**33**	**60**

Each participant was informed that their participation in the study was entirely voluntary and that they were able to withdraw from the study at any time. Information regarding each participant were kept confidential in accordance with the data storage requirements outlined in the University's Code of Research Conduct.

2.2 Questionnaire

Prior to the start of the study, a pre-session questionnaire has been sent to the registered participants to collect information about their prior VR experience and knowledge, including if they have ever used VR equipment and experienced motion sickness in the past.

After the pilot study session, participants were asked to fill out a post-session questionnaire to obtain information about their VR experience and if they developed any MS symptoms. Based on the responses, participants who experienced VRC were then asked to rate the severity of their symptoms on a scale from 0 to 5, where 0 means the particular symptom did not manifest and 5 means the symptom was very severe. Additionally, the participants were also asked to identify the possible factor that may have induced the VRC.

2.3 Pilot Study Design

Participants who volunteered to participate in the study was asked to select a predefined date and time slots to attend the V-Room pilot study. The pilot study spanned over the course of three weeks with two sessions allocated for each week, subject to the availability of the V-Room team personnel and participants. Prior to the study, the pre-session registration questionnaire was disseminated to the volunteers via an email message alongside the time booking slots.

The pilot study sessions were all conducted in the same controlled environment and approximately same environmental conditions to minimise data discrepancy between sessions. During the study sessions, participants were equipped with a mobile VR headset and audio listening device. A mobile phone with the V-Room application installed was provided for each mobile VR headset. The relevant specifications for each mobile phone used is outlined in Table 2.

Before the start of each session, participants were required to attend a briefing about the aims of the study, usage of the devices to be equipped, and health and safety advisory. When the participants were ready to undergo the V-Room experience, as shown in Figure 2, the team personnel assisted in equipping the VR headsets. Participants were also made aware of the possibility of VRC, which is a common occurrence that many people experienced during the use of VR equipment. Participants who developed unbearable reactions towards VRC during the session were allowed to either stop the V-Room experiential journey or resume the study after a short rest period.

Table 2. Mobile Phone Specifications Outline

Specification	Device A	Device B	Device C
Screen Display			
Type	AMOLED, 120 Hz	IPS LCD, 60 Hz	IPS LCD, 120 Hz
Size	6.9"	6.3"	6.67"
Resolution	1440 x 3088 pixels (~496 ppi density)	1080 x 2340 pixels (~409 ppi density)	1080 x 2400 pixels (~395 ppi density)
Platform			
Operating System	Android 10	Android 10	Android 10
Chipset	Qualcomm SM8250 Snapgradon 865+ (7 nm+)	Qualcomm SDM675 Snapdragon 675 (11 nm)	Mediatek MT6889Z Dimensity 1000+ (7 nm)
CPU	Octa-core (1x3.0 GHz Kryo 585 & 3x2.42 GHz Kryo 585 & 4x1.8 GHz Kryo 585)	Octa-core (2x2.0 GHz Kryo 460 Gold & 6x1.7 GHz Kryo 460 Silver)	Octa-core (4x2.6 GHz Cortex-A77 & 4x2.0 GHz Cortex-A55)
GPU	Adreno 650	Adreno 612	Mali-G77 MC9

The V-Room experiential journey app provided participants with an objective-oriented exploration of three types of classroom designs, where each classroom has a unique feature that participants could try. Each of these rooms vary in terms of colour and interior designs, exposing participants to different aspects of visual design in a virtual environment.

This experiential journey provided each participant with a series of "objectives" that they needed to follow. Once an objective was cleared, they were then able to continue to the next objective. The objectives were designed such that participants were guided through all of the rooms to test the available features. VRC were expected from a portion of the participants, since several of the features and aspects of the VR environment were known to induce VRC, such as bright colours, sensory mismatch, and levitation.

Each session lasted, on average, about 10-12 minutes per participants or until the participant decided to end the session due to VRC. The participants were then allowed to rest before asking them to fill the post-study questionnaire. V-Room team personnel were always present to assist the participants at any time during the pilot study session on a one-to-one ratio basis; that is one participant was supervised by one personnel.

Data from the questionnaires were then compiled and analysed by using the Analysis of Variance (ANOVA) F-test statistical analysis method whose results will be discussed in the following sections.

Fig. 2. Participant was equipped with the mobile VR headsets, courtesy of V-Room.

2.4 Statistical Method for Data Analyses

The ANOVA method was selected as the method to analyse the data that had been obtained from the study. The method was selected to investigate whether the two compared variables, *i.e.*, gender vs. VRC and study discipline vs. VRC, have statistical significance. The "significance" in the ANOVA test is hereby defined whether the variance between the two variables are significantly different from each other. In other words, the study investigates the influence of differences in gender and study discipline on the presence of VRC symptoms in the context of using a VR-based classroom for learning purpose.

This method uses two hypotheses, namely the null hypothesis (H_0) and the alternate hypothesis (H_1), to determine whether there is a statistically significance relationship between two variables (Larson, 2008; Pandis, 2015), *e.g.*, gender and VRC presence. Confidence level of 95% is used in this study, which means alpha (α) is 0.05. The results of an ANOVA would either be accepting or rejecting H_0. When H_0 is rejected, when p-value is smaller than the confidence level or when *F-statistic* value falls above F-critical (*F-crit*), it is said that there is a statistical significance in the data. If H_0 is accepted - thus rejecting the alternative hypothesis - it indicates that there is not enough evidence in the data to justify that there exists a statistical significance in the compared sets of data.

For the ANOVA hypothesis test, five more variables need to be introduced for the purpose of results presentation in Section 3, as follows.

- *SS* denotes the 'Sum-of-Squares', a measure of variation from the mean value of a set of data, computed by summing over the squares of the deviations from the mean.
- *df* denotes the 'degrees of freedom'.
- *MS* denotes the 'Mean Squares', which is computed by dividing the sum-of-squares over the given degrees of freedom.
- *F-statistic value* is calculated by dividing an *MS* over another *MS* value.
- *P-value* is the probability value of observing and comparing *F*-statistic value, which is obtained from the study, with the value of *F*-critical, hence, to determine whether to reject or accept the null hypothesis.

3 Results and Analysis

3.1 Overview

Through the completion of the pre-session and post-session questionnaires, it was identified that almost 50% of the study participants (28 out of 60 students) experienced VRC of varying severity. Out of 28, 16 of them had used a VR headset and experienced VRC, mostly in games, prior to coming to the V-Room pilot study session. Background of the participants who experienced VRC during the V-Room experiential journey is provided Figure 3. Based on the study disciplines these participants came from, 15 and 13 participants were from the Social Sciences and Natural Sciences, respectively.

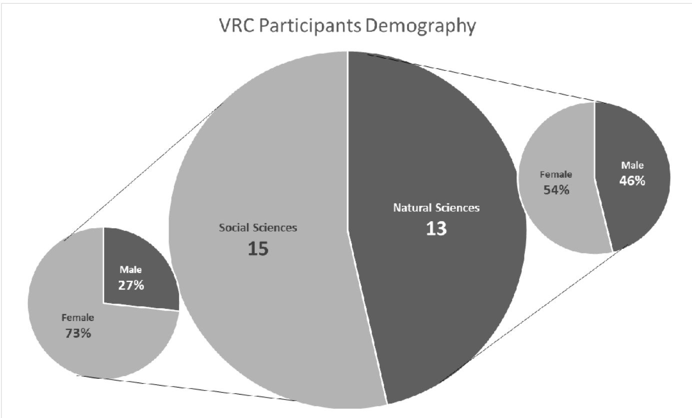

Fig. 3. Demography of the participants who experienced VRC during the V-Room study.

It could also be seen from Figure 3 that in both study disciplines, female participants were more susceptible to VRC than their male counterparts, *i.e.*, 73% females enrolled in the Social Sciences and 54% in the Natural Sciences. During the study, it was noted that all participants successfully completed the V-Room experiential journey session despite some having experienced VRC.

3.2 VRC Symptoms

The participants who experienced VRC during the pilot study were asked to rate their experience of each particular symptom on a scale of 0 to 5. Figure 4 illustrates the frequency of each symptom on participants. The graph also shows the distribution of each symptom on each gender. It is interesting to see that the most frequent VRC symptoms experienced by the participants were dizziness (25 participants) and discomfort (24 participants), followed by loss of balance and disorientation (19 participants, respectively). Meanwhile, the study also confirmed that female participants were at a higher risk in experiencing VRC than male participants.

Prior to analysing how significant demography of the participants affects the reaction towards VRC, the symptoms that were present were categorised based on the severity and commonness during a VRC experience. The results were then compared to one study conducted by Leung (2018), which provided an understanding on the pathophysiology and management of MS, as presented in Table 3. Symbol-coding was used to represent both the degree of severity and commonness and are explained in the legend below the table.

Based on the generated comparison, it could be seen that for most cases, the severities of the symptoms were similarly categorised, except in the cases of eye strain and sweating, which were respectively low-impact and medium impact in contrast to the medium-impact and high-impact that were described in the literature. Additionally, two of the symptoms that were observed in the study were not discussed in the literature and thus were not compared.

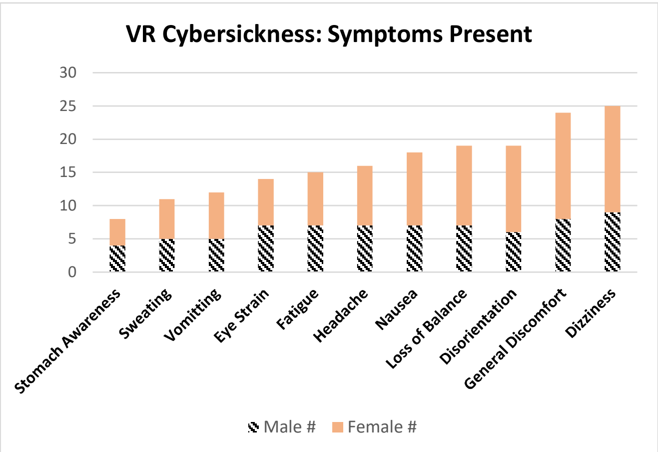

Fig. 4. VRC symptoms experienced by the V-Room study participants.

Table 3. Comparison of severity and commonness of VRC symptoms between literature data and data obtained in the study.

Symptoms	Literature*		Current Study: V-Room	
	Severity	*Commonness*	*Severity*	*Commonness***
General Discomfort	●	★★★★★	●	★★★★★
Fatigue	●	★★★★	●	★★★★
Nausea	■	★★★★★	■	★★★★
Eye Strain	■	★★★★★	●	★★★
Dizziness	■	★★★★★	■	★★★★★
Headache	▲	★★★★★	▲	★★★★
Disorientation	▲	★★★★	▲	★★★★
Sweating	▲	★★★	■	★★★
Vomiting	▲	★★★	▲	★★★
Loss of Balance	-***	-***	▲	★★★★
Stomach Awareness	-***	-***	■	★★

Legends for Severity:
● Low-Impact
■ Medium-Impact
▲ High-Impact

Legends for Commonness:
★ Least Common
★★★★★ Most Common

Notes:
* The data from literature in the table are summarised from the literature.
** Commonness threshold was determined based on the number of participants who experienced VRC.
*** These symptoms were not present or described as a part of other symptoms in the literature.

Looking at the commonness aspect of the symptoms, there is a consensus between the literature and the study that general discomfort and dizziness are very common amongst people who experienced VRC. One notable symptom that differs greatly between the literature and the study was the eye strain, where in the study, participants reported only low-impact and it was not as commonly observed as the other symptoms. To summarise, the severity levels of the VRC symptoms used in this study analysis are categorised as follows.

i. Low-impact: fatigue, eye strain, and general discomfort.
ii. Medium-impact: sweating, nausea, dizziness, stomach awareness.
iii. High-impact: headache, loss of balance, disorientation, and vomiting.

3.3 VRC vs. Gender

To understand whether gender manifests a certain significance towards VRC in the context of utilising the developed VR-based classroom, a one-way ANOVA was used to analyse the data obtained from the study. For this, each of the VRC severity category was analysed against gender, *i.e.,* female and male, as shown in Table 4. The null hypothesis suggests that there is no evidence for gender and VRC symptoms to be statistically different.

The results showed that for all three categories, the *F-statistic* values are significantly higher than the *F-critical* values, respectively from low-impact to high-impact: 38.927, 49.599, and 44.901 against 4.019, 4.019, and 4.019, which denotes that gender of the participants has a degree of significance when compared against VRC symptoms during the VR experience. In addition, this was further emphasised by the *p*-values, respectively 7.035E-08, 3.512E-09, and 1.26E-08, which are all below the value of α (0.05). This confirms the acceptance of an alternative hypothesis H_1 which states that there is a statistical significance between gender and the occurrence of VRC, therefore rejecting the null hypothesis H_0.

This finding is also supported by a study (Chattha & Shah, 2018) which has found that female participants have a greater chance of being afflicted by motion sickness while using VR. Another study by Chattha et al. (2020) further confirmed that gender is one of the statistically significant factors that plays a key role in the occurrence of VRC.

Table 4. One-way ANOVA of Gender vs. VRC symptoms with various severity levels: (i) low-impact; (ii) medium-impact; and (iii) high-impact.

Gender vs. Low-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	196.875	1	196.875	38.927	7.035E-08	4.019
Within Groups	273.107	54	5.058			
Total	469.982	55				

Gender vs. Medium-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	418.018	1	418.018	49.599	3.512E-09	4.019
Within Groups	455.107	54	8.428			
Total	873.125	55				

Gender vs. High-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	325.446	1	325.446	44.901	1.26E-08	4.019
Within Groups	391.393	54	7.248			
Total	716.839	55				

3.4 VRC vs. Study Disciplines

The relationship between study disciplines, divided into Natural Sciences and Social Sciences, and VRC symptoms is demonstrated in Table 5. The significance of these two sets of data is clearly demonstrated by having the *F*-statistic values (*i.e.,* 41.86, 52.16 and 47.53) larger than the *F*-critical value (*i.e.,* 4.02) for all VRC symptoms' severity levels, *i.e.*, low-impact, medium-impact, and high-impact. When calculating the total amount of Likert scale responses from the participants, it is also worth noticing that the medium-impact VRC received the largest responses from the study participants, indicating the most common symptoms experienced by the participants; its value was higher by 10.5% and 28.1% than those of high-impact and low-impact VRC symptoms, respectively. To support these results, it is also evident that the obtained *p*-values were of infinitesimal numbers, very close to zero, and were much smaller than 0.05. These statistical findings led to the rejection of null hypothesis, meaning the two sets of data, study disciplines and VRC symptoms, differed significantly from each other.

Table 5. One-way ANOVA of Study Discipline vs. VRC symptoms with various severity levels: (i) low-impact; (ii) medium-impact; and (iii) high-impact.

Study Discipline vs. Low-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	212.161	1	212.161	41.8618	2.98088E-08	4.019541
Within Groups	273.679	54	5.068122			
Total	485.839	55				

Study Discipline vs. Medium-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	440.1607	1	440.1607	52.16106	1.79437E-09	4.019541
Within Groups	455.6786	54	8.438492			
Total	895.8393	55				

Study Discipline vs. High-impact VRC

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	345.0179	1	345.0179	47.5323	6.11562E-09	4.019541
Within Groups	391.9643	54	7.258598			
Total	736.9821	55				

3.5 Potential Causes of VRC

To further investigate potential causes of VRC, participants were asked to select the factors that they believed might have contributed to the occurrence of VRC. In this study, the factors that are being reviewed were the speed of movements, angle of movements, lag, graphics quality, and bright colours/lights.

Speed of Movements. In most VR experiences, player movements, also known as locomotion, is an important aspect because it provides a way for users to move around in the virtual environment. The types of locomotion may vary depending on the VR experience. The locomotion method that this study used was gaze-controlled walking.

Angle of Movements. Since the locomotion method in this study relied on the participants moving their head and eyes to gaze as the control, any movements that occurred would be accompanied by a change in the gaze angle. As noted by Gavgani et al. (2018), the action of tilting one's head does contribute to the possible manifestation of motion sickness.

Lag. Lag, or more formally known as Motion-to-Photon (MTP) latency, is one of the causes of motion sickness in most computer-related systems, including in VR (Stauffert et al., 2020). Lag in this study is defined as the delay between the participant's head movement and the virtual changes that correspond to the head movement.

Graphic Quality. Graphic quality generally refers to the visually significant aspects that are present in the VR environment. As Burningham et al. (2002) has noted, any image that is shown or produced on a display or printer could be evaluated in terms of quality by their viewers. Thus, this study asked participants to evaluate the graphic quality of the VR environment and whether it contributed to the manifestation of VRC.

Bright Colours/Lights. The use of bright colours or lights may also be a factor for VRC to occur. A study by Bonato et al. (2004) concluded that chromaticity may affect how stationary an environment is being perceived as and may be a contributing factor to motion sickness. In addition, another study by Vasylevska et al. (2019) have noted that the brightness of a head-mounted display (HMD) may also contribute to cybersickness, although inconclusive at the time and requires further investigation.

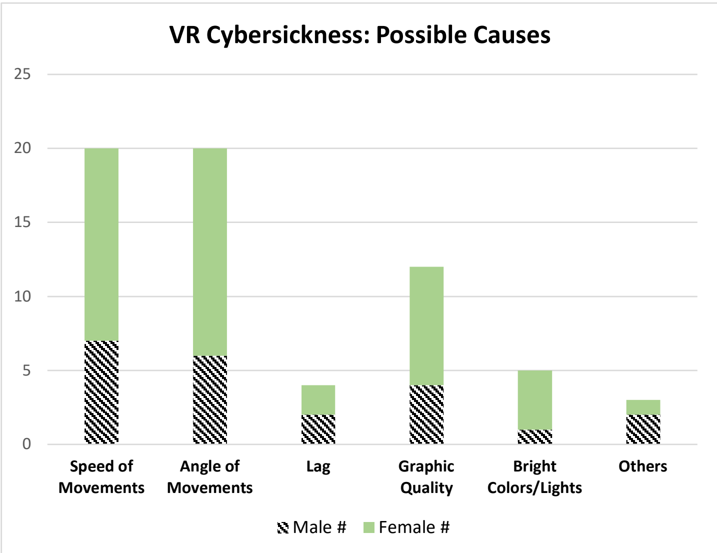

Fig. 5. Feedback from the participants regarding potential causes of VRC.

Table 6. Possible Causes of VRC and the Proportions of Male and Female Participants who Reported that Particular Cause.

Possible Causes	Male %	Female %
Speed of Movements	70%	72%
Angle of Movements	60%	78%
Lag	20%	11%
Graphic Quality	40%	44%
Bright Colours/Lights	10%	22%
Others	20%	6%

As reported by the participants in the study, the possible causes of VRC have been documented and illustrated in Figure 5 above, with 20 participants, each, reporting that speed of movements and angle of movements were a major cause of their VRC, followed by 12 participants who reported graphics quality, 5 reported graphics quality, and lag being the least likely to cause VRC with only 4 participants reporting it. Additionally, three other possible factors have been identified by three participants, namely: *"user control experience"; "levitation";* and *"*[use of] *mixed colours".*

In terms of the differences of possible causes of VRC amongst male and female, it was observed that a higher proportion of female participants believed that all of the factors, except lag, was the cause(s) of their VRC (shown in Table 6 above).

Some participants were asked about their use of the V-Room app and their experience of VRC during the study. One participant commented that "*the motion can be better*", while another agrees that "[sic] *the movement can be less dizzy*". When asked about what they believe could alleviate their VRC, one participant said, "[using] *high tech* [equipment] *to prevent sickness like [dizziness] and other uncomfortable symptom*", implying that a better hardware may be a key to reducing the occurrence of VRC.

4 Conclusion and Future Work

Pilot study conducted by the V-Room team focused on investigating the cybersickness effects of using a VR-based virtual classroom, has been completed. The aims are threefold:

i. Identification and qualitative analysis of the VRC symptoms;
ii. Statistical significance analysis of students' demography, *i.e.*, gender and study discipline, when compared against the occurrence of VRC symptoms;
iii. Understanding the potential causes that strongly contribute to VRC.

Responses received through the given questionnaire demonstrated that 46.7% participants, university UG students at UNNC, were affected by VRC symptoms when immersing themselves in the developed VR-based classroom. Based on the severity and commonness levels of VRC classification proposed in this study, medium-impact VRC received the highest number of responses from the study participants. This category includes sweating, nausea, dizziness, and stomach awareness. When assessed individually, out of 11 VRC symptoms considered, dizziness was the most frequent symptom experienced by the participants. It is also worth mentioning that around 53.6% participants who experienced VRC came from the Social Sciences study discipline, a slightly higher percentage compared to participants with Natural Sciences background. In both cases, female participants were particularly found to be more prone to experiencing VRC.

One-way ANOVA results obtained from this study suggest that both gender and study disciplines offer statistical significances against the presence of VRC when a VR-based classroom is used by the university students in the T&L context. It is therefore worth considering the two factors, such as when developing a virtual environment for the students equipped with VR technologies.

Further investigation of the V-Room project would include the exploration of whether the presence of VRC influences the learning experience of these students, other factors that might correlate to VRC, and potential ways on minimising or reducing the effects of VRC on using a VR-based classroom. By understanding the preliminary results of the presence of VRC symptoms and potential causes of VRC from this study, especially in the Higher Education sector applications, it is hoped that the key findings can be used as a guideline for designing and developing an effective virtual learning environment.

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A Pilot Study Investigating Students' Perception of a Virtual Classroom Environment in Higher Education

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Abstract
Purpose – Virtual reality (VR) offers many desirable features for education, including an immersive and low-distraction experiences, and visually-attractive virtual environments. This paper reports on a pilot study investigating student response to VR in higher education (HE). It is part of an ongoing university-scale project, named V-ROOM, which aims to develop a comprehensive VR teaching and learning (T&L) platform, which aligns with the digital T&L transformation strategy at the first Sino-foreign HE institution in China — the University of Nottingham Ningbo China (UNNC).
Design/methodology/approach – This study involved 55 undergraduate students — 21 in engineering programmes, and 34 in non-engineering programmes — being immersed in a virtual classroom environment (VCE). The instrumentation included a Likert-scaled survey and follow-up interviews. The survey explored the overall student perceptions of the VCE, and this was followed by an interview that enabled clarification and expansion of the responses. Response data were evaluated across four factors: learning motivation; engagement in the learning journey; the attraction of the VCE; and satisfaction with the VR experience. Correlations were also analysed between students' overall perception and various other elements (including VCE features, gender, and study programme).
Findings – The reliability of the survey data was examined using Cronbach's coefficient, which was greater than 0.8 for all factors, confirming the internal consistency of the set parameters. The results also showed that students had a very positive attitude towards using VR for learning, with an average score of 4.01/5.00. The VCE features, which involved a multi-sensory experience, appeared to have a higher positive correlation with the students' overall perception than gender or study programme, with the visual features being the strongest influence compared to interaction (kinesthetic) or audio (auditory) features of the VCE.
Originality/value/implications – The results of the pilot study showed that the respondents, who were 18 to 21 year old UNNC undergraduate students, had an overall positive perception and learning experience of using VR for HE T&L activity, especially in the context of integrating multi-sensory learning elements in the VCE developed. The key findings from the current study will be used to enhance the VCE interaction features that will support a variety of students' learning styles and expectations for a virtual classroom. In a broader context, the authors hope that this paper will contribute to providing a pedagogical infrastructure where the use of VR for learning is not a binary

option; rather, it could be implemented as an innovative digital T&L method, complementing conventional T&L, and the existing online and blended learning strategies.

Keywords: virtual reality, virtual classroom, student motivation, reliability and correlation analyses, multi-sensory learning

1 Introduction

VR technology has been widely used by various institutions, including companies, hospitals, schools, universities, and other training centres for different purposes. Gaming, entertainment, and education are among the most popular areas of VR applications (Baxter and Hainey, 2019). For instance, many recent studies investigated VR usage in the medical field, where VR is not only used for training and teaching in medical-related study programs, but also used as a supporting aid for the disabilities.

Such practices of using VR for medical and nursing study programmes are expected to enable students to gain the experience of conducting a procedure or a surgery without putting a patient's life in danger. Hence, with the support of VR technologies, one could experience a more realistic and interactive environment, compared to watching training videos or reading instructional books, which are the usual approaches for training clinical competences (Choi, 2019). A study conducted by Salsabeel (2018) also made a comparison between a VR heart anatomy system and a traditional medical teaching which concluded that VR could better visualize complex anatomical structures and provided a better understanding for the users.

VR has also become one of the main methods used to treat mental disorders, trauma, and to meditate. VR therapeutic benefits are reflected in different applications, one of them is a VR classroom developed to assess the performance of children diagnosed with Attention/Deficit/Hyperactivity Disorder (ADHD) in their Continuous Performance Tasks (CPTs). VR could provide the tests in a standardized classroom environment under a fully supervised conditions, thus making the results more accurate compared to the actual environment (Adams, et al., 2009).

Due to its interactive nature, VR often gives more motivation and engagement to their users, which in turn increase the efficacy of the trainings. The participants of VR-based Traditional Dialetical Behavioral Therapy (DBT) mindfulness training, who often have trouble focusing their attention, showed a significant rise in their mindfulness and emotional states (Navarro-Haro et al., 2017). In this therapy, VR successfully eliminated the lack of motivation to practice, and effectively treated the patients (Navarro-Haro et al., 2017).

The usage of VR is not limited to healthcare education but has also been extended to virtual classrooms in schools or Higher Education institutions. Most existing studies focused on the usage of VR in Science, Technology, Engineering, and Mathematics (STEM) related study programs. STEM education is often closely related with physical and hands-on-experiences, which are one of the limitations in the remote learning environment. VR have filled these gaps by visualizing the real-world problems and allowing the users to do their experiments with minimum damage

(Carruth, 2017). One related application is the use of VR in the military industry, which utilizes simulations in VR for military trainings. VR could bring realistic situations that are challenging to perform in real trainings, such as equipment malfunctions and exposure to dangers while allowing the users to experience the effects immediately (Lele, 2013). Furthermore, a study demonstrated that VR approach in the Project Based Learning (PBL) significantly increased students' performance and interpersonal communication (Halabi, 2020).

Looking at the potentials of using VR-based virtual classroom, students' perceptions of using VR in the Higher Education classrooms vary from one to another; however, it is evident that their responses towards educational VR are generally positive (Hagge (2020), Baxter and Hainey (2019), Alfalah (2018), Domingo and Bradley (2018)). In the study done by Oiwake et al. (2018), participants were exposed to three types of classes (real-world classes, remote classes, and VR classes), and results suggested that VR classrooms could increase students' motivation, and VR scored the highest in terms of Relevance and Satisfaction.

Another example comes from an incorporation of Google Earth VR in Higher Education (HE) which has received positive feedbacks about this revolutionary learning method, especially in terms of immersion (Hagge, 2020). An immersive VR is defined as a VR in which the user has a sense of being present and is able to interact with the virtual environment (Hamilton, et al., 2021). In most cases, VR users also experience reduced spatial awareness. Nevertheless, it was emphasized that the VR should not completely replace traditional classrooms but should attempt to support the formation of a conducive learning environment instead (Hagge, 2020). This is mainly because there still exist issues associated with VR, such as costs, hardware and self-technical skills, and health issues as motion sickness and disorientation (Baxter and Hainey (2019), Lanzo et al. (2020)).

Even though the advantages of VR clearly outnumber the disadvantages, it does not mean that VR does not possess any risks and drawbacks. The challenges of using VR as a teaching and learning tool in the classrooms, however, have been discussed by previous researchers, which demonstrate that there are similarities between academic staffs and students' responses. Cooper et al. (2019) reported that 37% of their participants, who were preservice teachers, were unconfident about their own self-efficacy to use VR in their teaching, since it might be more difficult to control the classroom. Similarly, most student participants experienced technical difficulties when being in the virtual space, despite 86% gave positive perceptions due to increased participation and sense of being in the same space with their classmates (Domingo and Bradley, 2018). In addition, the teaching and learning conducted in virtual environments may offer less flexibility compared to the traditional teaching, since the interaction is mostly one-sided (Kamińska, et al., 2019). Some students may ask questions and discuss about the teaching content; however, this is not offered in most VR.

In the pedagogical perspective, motivation is an essential factor in teaching and learning, and it determines one's persistence to achieve the learning goals (Filgona, et al., 2020). Previous studies (Sattar et al. (2019), Gargish et al. (2020), Sancho, Torrente, and Fernández-Manjón (2009)) have underlined that VR learning environment could enhance students' motivation. This paper uses the ARCS model, which describes the four components; (1) Attention, (2) Relevance, (3) Confidence, and (4) Satisfaction for learners to stay motivated as one of the bases to design the pilot study questionnaire (Keller, 1987).

Attention is generally classified to several forms (Chen and Wang, 2018), and among these forms, sustained attention is the form of attention that has been used as the topic of various studies. Sustained attention is defined as how a human being maintains to stay alert and receptive of stimuli over prolonged periods of time (Fortenbaugh, DeGutis, and Esterman (2017)). It is often linked with learning (including e-learning) since it is related to how learners stay attentive in the classrooms, and researchers have argued that attention is strongly correlated with academic performance (Börner, Kalz, and Specht (2014), Corno (1993), Chen and Wang (2018)).

Research has proven that there exists a positive correlation between attention levels and engagement in classroom activities (Sezer, et al., 2017). A highly motivated student shows high attentiveness and class participation (Schunk, 2008), which is why examining one's attention is crucial. Kamińska, et al. (2019), Ruiz-Cantisani et al. (2020), and Allcoat and von Mühlenen (2018) have highlighted that the use of VR and other digital technologies in classrooms increase students' engagement and involvement, which are particularly useful in blended learning situations. A study done by Ruiz-Cantisani et al. (2020) have reported that 91% of their student participants would like to use VR in other modules, in addition to their engineering modules.

On top of causing a rise in student engagements, Allcoat and von Mühlenen (2018) also reported that students who use VR in their learning showed improvements in their overall experiences compared to those who use textbooks or video as their tools. This is aligned with the findings of Cooper and Thong (2019) which suggested that other forms of educational tools might not obtain better responses and higher students' engagements when compared to the VR environments, which offers multi-sensory experiences for its users. There is concrete evidence that show how VR enhances learners' motivation, engagements, and overall satisfaction, but the features available in the VR may be a determining factor of one's perception.

Based on the review of immersive VR applications for higher education by Radianti et al. (2020), basic interactions and realistic surroundings are the features that are embedded in most VR used in higher educations, 24% and 17% respectively. The basic interaction allows users to select and interact with the virtual scene, such as obtaining information about the object, lifting, rotating, zooming in or out, and modifying the attributes of the objects (Li et al., 2019). The realistic surrounding in VR is designed to replicate a specific environment in the real world through the simulation of humans' perception (Pujol, 2011). The next design element that is included is the immediate feedback and instructions Radianti et al. (2020). This is closely related to the Relevance component in the ARCS model, which suggests that presenting materials and instructions in a clearer way could help students to better understand their learning content (Keller, 1987).

Thus, the current study presents results on students' perception towards using VR VCE for learning based on four components, including learning motivation; learning journey engagement; VCE attraction; and VR experience satisfaction. These components are selected to investigate not only the pedagogical perspective on how to accommodate the enhancement of student learning experience in the context of online/blended learning environment in the Higher Education (HE) Teaching and Learning (T&L) practices, but also on how students react towards embedding the VR technologies into the classroom.

2 Data Collection of the Pilot Study

The pilot study was conducted in the autumn semester of the university academic year of 2020/2021. The target participants of the pilot study is undergraduate university students at the University of Nottingham Ningbo China (UNNC).

2.1 Participants

Having received the full approval from the UNNC Research Ethics Committee, participants were invited to voluntarily participate in this pilot study via email, noting that they were not required to have any prior knowledge or experience with the VR technology utilization. The volunteers were recruited based on a first-come, first-served basis registration within the given timeframe. From 55 students who were selected to participate in the study, it is interesting to find that 66.67% students reported that this pilot study was not the first time they used VR, while 33.33% students had no prior VR experience in any way.

2.2 Pilot study session

Prior to being equipped with the VR headset, the student participants received a thorough briefing about how the procedures of the pilot study are being conducted, the aims of the pilot study, how long they would be wearing the device, content of the VCE, and what they should do if there were any problems during the session. Afterwards, the participants were exposed to the VCE and equipped with a mobile VR headset with an action button available on the top-right of the headset and a joystick to control the virtual movement of the participants which are limited to forward-backward-leftward-rightward functions. Duration of the VCE exploration was about 10 to 15 minutes per participant.

During the session, participants were asked to complete some quests related to virtual classroom features, such as answering short quizzes by clicking on objects, viewing images, picking up/throwing an object, and watching video contents. There were several checkpoints to be visited by the users, and the goal was to accomplish all the quests; instruction was provided as the participants entered the virtual lobby of the VCE, as illustrated in Figure 1. The quests were designed to familiarize the participants with the classroom features in the virtual world.

Fig. 1. View of the virtual lobby of the VCE from the VR headset, courtesy of V-ROOM

2.2 Questionnaire design and data collection

The final step of the pilot study was the post-session questionnaire. The participants were asked to give their honest feedback about the prototype. The questionnaire consisted of 40 questions, including the information sheet and participants' agreement, personal details, and questions investigating the experience of the participants after exploring and experiencing the developed VCE prototype. In the information sheet, participants were also informed that all the information provided in the questionnaire will be kept confidential and only used for research purposes. As mentioned in the previous section, the questions are focused on motivation, learning journey engagement, attraction to using VR in learning, and the overall satisfaction of the learning experience using VR.

The authors of this paper decided to use the questionnaires to obtain participants' feedback since they are thought to be widely used, quick, and efficient to acquire information from a large sample of people. The types of questions in the questionnaire included Likert-scale and open-ended questions. Participants could give their ratings on the motivation, engagement, attraction, and overall satisfaction using the Likert scale, and express more elaborations on their answers in the open-ended questions. The ratings of the Likert scale were on the scale from one to five, with one being the lowest, and five being the highest, *e.g.*, one for being not motivated at all, and five for being very motivated to learn.

3 Results and Discussions

In this section, the study results of using a VR-based VCE will be discussed based on four learning factors that represent the overall students' perception; they are: (i) *learning motivation*; (ii) *learning journey engagement*; (iii) *VCE attraction*; and (iv) *VR experience satisfaction*. Detailed results for each aforementioned factor, including variable's quantity, tables, and graphs, will be discussed in the following sub-sections by using descriptive statistics approach.

Prior to conducting an analytical deduction, a statistical approach named Cronbach's alpha (Cronbach, 1951) is used to examine the reliability of the obtained survey data. Cronbach's alpha, also known as Tau-equivalent reliability or coefficient alpha, is considered as 'one of the most important and pervasive statistics in research involving test construction and use' (Cortina, 1993, p. 98), and it has been the most commonly used coefficient to measure attitudes and other affective constructs (Taber, 2018). The formula of Cronbach's alpha is as follows.

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_T^2}\right), \tag{1}$$

where k is the number of scale items, which in this case is 55, while s_i^2 is the variance associated with the i-th item and s_T^2 is the variance associated with the total score of the scale items. The value of Cronbach's Alpha will be in the range of 0 to 1.

In this work, Cronbach's Alpha is used to analyze two different scale sections of the questionnaire: (i) Students' Perception, which includes learning motivation, learning journey engagement, VCE attraction, and VR experience satisfaction; and (ii) VCE Features, which consists of visual, interaction, and audio.

Table 1. Reliability analysis by using SPSS® Statistics for "Students' Perception".

Cronbach's Alpha	Items	Item Statistics	Mean	Standard Deviation	k
0.828	4	Learning Motivation	3.982	0.972	55
		Learning Journey Engagement	3.946	0.931	55
		VCE Attraction	4.109	1.066	55
		VR Experience Satisfaction	4.000	0.861	55

Table 2. Reliability analysis by using SPSS® Statistics for the "VCE Features".

Cronbach's Alpha	Items	Item Statistics	Mean	Standard Deviation	k
0.916	3	Visual Feature	3.764	0.9269	55
		Interaction Feature	3.670	0.9439	55
		Audio Feature	3.773	0.9917	55

As shown in Tables 1 and 2, the results, which were processed by using SPSS® Statistics, confirm the reliability of the data whereby the Cronbach's Alpha values were found to be 0.828 and 0.916 for the respective Students' Perception and VCE Features data. Argued by Joseph and Rosemary (2003), an alpha of 0.8 and above could be a suitable criterion to present the internal consistency of scale items; hence, the higher Cronbach's alpha coefficient, the greater the reliability of the data. Moreover, Taber (2018) summarised in his paper that many researchers accepted 0.7

as a rule-of-thumb to demonstrate the internal consistency of scale items. As a result, the following observations and discussions are supported by the reliability of the survey data collected from this study.

3.1 Students' Perception of the VR-based VCE

As shown in Table 1, participants had demonstrated an overall very positive attitude and perception towards using VR for learning, with an average score of 4.01/5.00. Despite not many empirical investigations have yet been conducted in the applications of VR for formal T&L activities, studies published by Webster (2015) and HTC Vive (2016) had found that groups of students who experienced an immersive VR-based environment had a higher learning improvement, by about 15% to 20%, when compared to those exposed to the traditional approach. Similarly, Allcoat and von Mühlenen (2018) as well as Benton, Duchon, and Pallett (2013) had also confirmed in their studies that participants in the VR environment were found to be better at remembering and understanding the learning contents, in comparison to those in the video and traditional learning conditions.

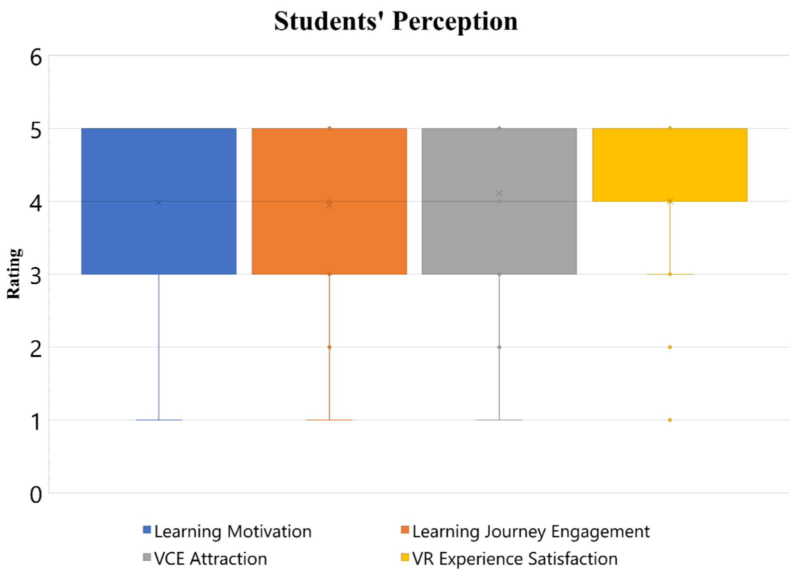

Fig. 2. Data presentation of the students' perception factors by using boxplot for: (a) learning motivation; (b) learning journey engagement; (c) VCE attraction; and (d) VR experience satisfaction.

Learning Motivation. Motivation has been described in various ways as the essence of learning which can strongly influence the outcomes of learning itself (Paris & Turner, 1994; Brophy, 2010; Schunk *et al.*, 2014), especially in the context of an online or a distance learning success (Artino, 2008; Keller, 2008). As identified by Moore (1994) and Hillman et al. (1994), interactions such as learner-instruction, learner-content, learner-learner, and learner-interface are essential requirements to deliver an effective learning environment. These interactions cannot be fully achieved by using a typical online platform where access to the physical space and interactions amongst peers are very limited, but through a video call-like scenario equipped with a screen-sharing feature. However, the VR-based VCE allows the students to be immersed in the virtual environment where such interactions become possible through the simulations of real-world scenario. It is therefore expected from this study that the use of immersive VCE may enhance the overall learning experience, including learning motivation.

The outcomes of the survey, demonstrated in Figure 2(a), present that the students' learning motivation factor has a mean value of 3.98/5.00, indicating that the study participants have a relatively medium-to-high motivation towards using VR for learning. Other parameters were noticed, including a median value of 4.00 shown by the '×' point, and a standard deviation of 0.93. As demonstrated, these findings also indicate generally positive responses from the participants which are bigger than a half of the total score, *i.e.* 2.50, as the majority of the responses are concentrated on the top half of the scale. This rather positive feedback suggests that VR-based VCE can improve students' learning motivation, especially in the context of distance or remote learning. There are also a number of optional comments which are worth highlighting, such as when over 50% of the participants consider the VCE as a new and innovative way of learning, and that they find using VR in the classroom is a very interesting way to learn that made them feel more motivated and interested to study. The emphasis made by the participants regarding their "interest" in utilizing a VR-based VCE is indeed an advantage as previous research has found a close relationship between interest and motivation in learning which has a significant impact on the learning experience and performance (Hidi & Renninger, 2006).

The data gathered from the questionnaires showed that most participants found it interesting to use VR for their learning because that was something new for them, thus increasing their motivation. It could be seen that the cause of the rise in motivation varied from one student from another. Some of the interesting feedbacks include:

VR enables its users to play and learn at the same time,

> *"VR merges playing and learning, thus making people less bored when learning. When I am in the virtual environment, I can just go around and pick up an object when I am bored or exhausted after my studies."*

VR enables its users to interact with others, and

> *"VR enables students to do some interactive activities in the virtual world. It also makes it possible for people being in different locations to interact with each other."*

VR enables its users to visualize their job.

> *"I can experience the daily work of an accountant, or any other occupations, and have clearer visualizations of my future career choices."*

Learning Journey Engagement. The next factor is the learning journey engagement of the participants towards the developed VR-based VCE. As shown in Figure 2(b), learning journey engagement receives a similar perspective as that of the learning motivation with an average rating of 3.95 and a mode of 4.00 out of 5.00. These findings indicate the positive attitude towards engaging with the learning journey provided by the VCE, and are consistent with those of learning motivation and previous research, which stated that learning engagement can be enhanced through using VR (Benton, Duchon, and Pallett, 2013; Strydom, Mentz and Kuh, 2010; Wolf-Wendel, Ward and Kinzie, 2009). Most participants reported that their learning in VR was more engaging and interesting compared to the traditional way of teaching, although some components of the developed VR-based VCE still required some improvements. Some students also mentioned that they were expecting more instructions to guide them from one task to another, and to see which tasks they had accomplished whereas a few others mentioned that the incorporation of video, music, and interaction with the environment while undergoing the learning journey in the VR environment have made them feel more involved and engaged. Examples of the comments are as follows.

Having more instructions in the virtual classroom would be helpful and engaging, and

> *"Sometimes, I do not know which room I am in, and whether I have explored that room or not. Some indications of whether or not I have completed the checkpoints will be helpful."*

> *"The annotations for each place in the virtual classroom attract my attention, and the feature that enables me to move objects in the room freely is really engaging!"*

Some features such as body movements, decorations, and activities still needed some improvements.

> *"The engagement is good when watching videos and listening to the audio, but the lack of body movements can remind me that the world is not real. I also feel some differences on my vision when I am in the virtual classroom."*

> *"I think the VR classroom is interesting, but it is still lacking some wall decorations. The games in the classroom are too simple, so there is still some room for improvement."*

The VR environment is suitable for learning.

> *"The environment and atmosphere created by the VR is attractive and suitable for learning. The function of playing the video, viewing the pictures, and answering the short quiz by clicking on the board are good interactive activities.*

VCE Attraction. Figure 2(c) presents the boxplot of the students' VCE attraction factor. VCE attraction shares the same boxplot with the former two factors, learning motivation and learning journey engagement. However, its mean value receives the top-most rank, 4.11/5.00, indicating that the VCE learning attractions successfully attract the study participants and help improve the learning experience. In the meantime, the standard deviation is found to be 1.07 while the median value remains the same as those of learning motivation and learning journey engagement. As demonstrated, these findings also indicate generally positive responses from the participants for over a half of the total score, *i.e.* 2.50, as most of the responses are concentrated on the top half of the scale.

Further clarifications were also asked from the participants where the majority of the participants reported that they felt more attracted to learning in VR compared to the traditional teaching, because VR is not only interactive but also able to help them to memorize things better through 3D visualization. However, there still exists some drawbacks such as motion sickness, dizziness, and vision problems when wearing the VR gear for a longer time. One of the students also mentioned that VR might be a more suitable and efficient approach to present practical learning contents, but it would be challenging for subjects such as literature, *e.g.*, when note-taking activities are required. From the pilot study, participants gave their feedback on some features they would have desired to be present in their classroom activity, which include:

More advanced teaching and learning content, and

> *"I would like to visit some exhibitions in the virtual world, I think it will help me to study better in the virtual world. Or maybe, it would be great if I could join some classes from other universities."*

more interactions.

> *"There are a wide range of activities in the virtual classroom. However, in today's experience, there is only one person and I cannot have any social interactions. I would like to be more engaged by communicating with some people in the virtual world."*

VR Experience Satisfaction. Figure 2(d) presents the boxplot of the students' VR experience satisfaction factor. It is noted that the boxplot differs significantly than other boxplots. There are two points of outliers, and responses are concentrated in the range of 4.00 to 5.00 for all data from the second quartile to the maximum. As a result, throughout all four different factors, the response of survey participants to this factor is the most positive, indicating almost all of them satisfied that piece of VR learning experience and it would be useful if the VR technology could be introduced to students' daily learning life in higher education. Other parameters of the factor are the following, mean value 4.00/5.00 and standard deviation 0.86.

When asked individually regarding their overall experience towards the use of VR-based VCE, most participants claimed to have been satisfied with the virtual classroom. Even though two-third of the participants had prior VR experience, over a half of them mentioned that there were some features associated with the use of VR that surprised them, and they would want to see in the campus environment, *i.e.* UNNC. Some students also mentioned that they were highly inspired by the overall VR development and the idea to apply VR for teaching and learning purposes. Other valuable comments include how the participants received a sense of reality through exploring the VCE, with interaction being the strongest positive point of this usage. Several feedbacks are highlighted below.

> *"The operation of the VR headset is quite easy and user-friendly. The movements in the VR are also quite similar to the reality, so the goal of 'experiencing the reality from the headset has been achieved."*

> *"To be honest, I have experienced many VR contents before, such as Alyx (Valve Corporation), Astro Bot Rescue Team (Sony Interactive Entertainment), so I cannot say that the features really 'surprised' me. But the idea of applying the VR technology into teaching definitely surprised me!"*

3.2 Correlation Analysis of the Students' Perception against Learners' Attributes

This section investigates whether the two learners' attributes, *i.e.*, gender and study programme (course), have any correlation towards the overall students' perception. Data distribution of the considered parameters is presented in Figure 3. It can be seen that the first quartile of the students' perception, represented by the bottom whisker, is lower for students enrolled in the non-engineering course. The median values, nonetheless, for all boxplots are 4.0, except for VCE attraction data obtained from the engineering students with the median of 5.0, and a 4.5 for the female non-engineering students. The weight, represented by the thickness of the boxplots, is varied due to the sample size differences amongst each category. However, the second and third quartiles of data are generally well-spread below and above the median, although it is noticed that 4 out of 8 boxplots associated with engineering students are top-skewed, which means that students' perception data in this category are concentrated on the top-half of the distribution. Another interesting plot is from the VR experience satisfaction for female non-engineering students, where all data are highly concentrated around the median (a small sample size), except for the respective three outliers found below (who rated 3.0) and above it (who rated 5.0).

Pearson product-moment correlation coefficient (r) is used to further analyse the correlation of the variables in pairs. The result will be ranging from -1 to 1. The nearest the value to -1 or 1, the stronger the correlation is whereas a value of 0 means there is no correlation between the two sets of data. The correlation will also be supported by p-value and t-statistic value, as a result of one-tailed t-test, which are part of the statistical hypothesis test. In this case, to determine whether to accept or reject the null hypothesis which states that there is no significant difference between the two sets of data, p-value and t-statistic value will be respectively compared against the confidence level of the test ($\alpha = 0.05$) and t-critical value. Given the sample size is 55, hence the degree of freedom is 53 while the t-critical value is found to be 1.6746.

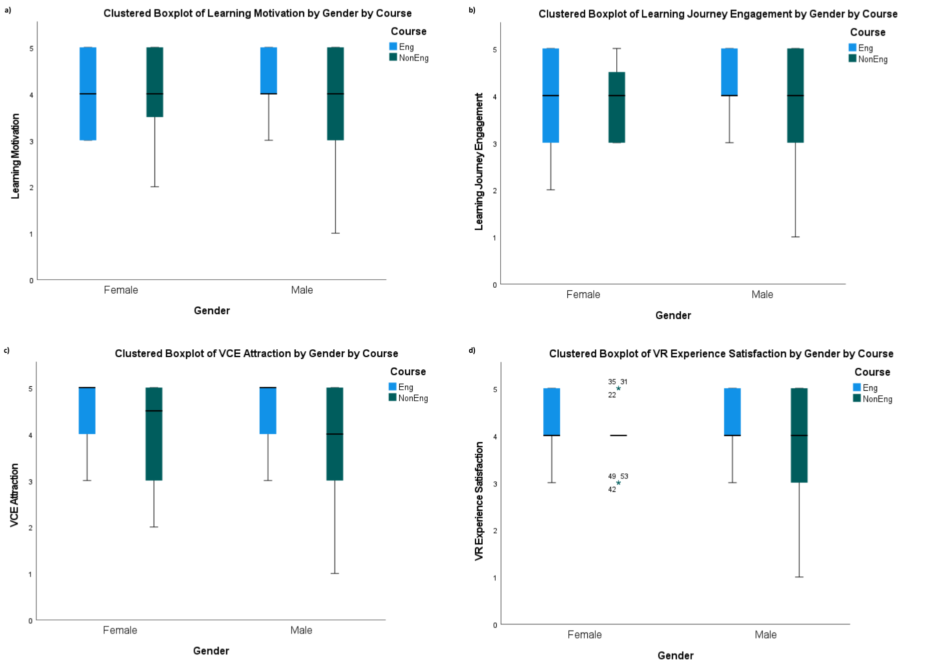

Fig. 3. Boxplot of the students' perception factors against gender and study programme (course) for: (a) learning motivation; (b) learning journey engagement; (c) VCE attraction; and (d) VR experience satisfaction.

Table 3 demonstrates that the overall students' perception is correlated to gender and study programme by 30.63% and 19.44%, respectively. These values are considerably closer to 0, hence a relatively weak but positive correlation is present. The statistical results, *i.e.,* p-value and t-statistic value indicate that the data sets between students' perception and gender reject the null hypothesis, agreeing that the means are significantly different. This is due to both 1-tailed and 2-tailed p-values are all smaller than 0.05, and t-statistic value is found to be larger than t-critical value. On the contrary, the investigation against the study programme proves otherwise, that is to accept the null hypothesis. The evidence suggests that gender has a stronger correlation and produces different mean to the overall students' perception towards VR-based VCE, when compared to study programme.

Table 3. Correlation of the overall students' perception against learners' attributes.

Overall Students' Perception VS.	Pearson Correlation (r)	P-value (1-tailed)	P-value (2-tailed)	t-statistic
Gender	0.3063	0.0114829	0.0229659	2.3421
Study Programme	0.1944	0.0774502	0.1549005	1.4430

3.3 Correlation Analysis of the Students' Perception against VCE Features

Here, the correlation of the students' perception will be investigated against both overall and individual VCE features, including (i) visual properties; (ii) audio; (iii) VR human-object interaction, as shown in Table 4. These features touch upon multi-sensory experience of the learners, aligning with three out of four learning styles of the students modelled by Fleming and Mills (1992); they are VAK: Visual, Aural/Auditory, and Kinaesthetic learning styles.

As demonstrated, the Pearson correlation coefficient for the overall students' perception against the overall VCE features is found to be 0.5864, indicating there exists 58.64% positive correlation. This correlation is much stronger compared to those resulted from gender and study programme. Similarly, when investigated against each of the VCE features, their correlation coefficients with the overall students' perception are found to be 59.61%, 48.41%, and 45.12% for the respective visual properties, audio, and VR human-object interaction.

Visual properties appear to be the strongest contributor to this correlation, which means that the visualisation aspect of the VCE will have a higher influence towards the overall students' perception than audio and human-object interaction features. This is again aligned with previous findings from various studies that confirm a higher percentage of learners falls under the category of visual learners and that the use of visual aid or visual information would better stimulate students' ability to capture and memorise the learning content for numerous reasons (Dunn and Dunn, 1978; Cuban, 2001; Ibrahim and Hussein, 2015). As also demonstrated in Table 4, the p-values and t-statistic value for the VCE features data obtained from the analysis must reject the null hypothesis. Thus, the significant difference between the overall students' perception and the VCE features are not just by chance.

Looking at the significance between the overall VCE features and each of the students' perception factors, as presented in Table 5, VR experience satisfaction and learning journey engagement had moderately higher correlations than those of VCE attraction and learning motivation. It is also worth noting that since all p-values are smaller than 0.05 and t-statistic values are larger than t-critical value, the null hypothesis is rejected, hence it is evident that the means of two compared variables in Table 5 are statistically different from one another.

Table 4. Correlation of the overall students' perception against VCE features.

Overall Students' Perception Vs.	Pearson Correlation (r)	P-value (1-tailed)	P-value (2-tailed)	t-statistic
VCE Features	0.5864	0.0000013	0.0000025	5.2706
Visual Properties	0.5961	0.0000008	0.0000016	5.4044
Human-Object Interaction	0.4841	0.0000902	0.0001804	4.0281
Audio	0.4512	0.0002728	0.0005456	3.6807

Table 5. Correlation of the overall VCE features against students' perception factors

VCE Features Vs.	Pearson Correlation (r)	P-value (1-tailed)	P-value (2-tailed)	t-statistic
Learning Motivation	0.3493	0.0044746	0.0089492	2.7140
Learning Journey Engagement	0.5425	0.0000094	0.0000188	4.7014
VCE Attraction	0.4615	0.0001952	0.0003904	3.7873
VR Experience Satisfaction	0.5735	0.0000024	0.0000047	5.0960

4 Conclusions and Future Work

The unfortunate COVID-19 situation has increased the demands of non-conventional teaching and learning approaches to accommodate the needs for online learning, blended learning, and other distant learning environments. VR is one of the immersive technologies that caught the attention of educators. Hence, the investigation of using a VR-based VCE with respect to the students' perception was studied in this paper, developed under a university-scale V-ROOM project. As an on-going research and development, V-ROOM aims at enhancing student learning experience through embedding VR technology in the context of T&L activities. Key findings identified from the current study are as follows.

(i) The reliability test was primarily conducted to two sections of scale questions including students' perception and VCE features; Cronbach's alpha were found to be 0.828 and 0.916, respectively, larger than 0.80, hence confirmed the collected data were reliable to undergo further statistical tests.

(ii) Overall students' perception was 4.01 out of 5.00 scale, indicating a considerably positive response of the students towards using a VR-based VCE.

(iii) Correlation analysis was conducted between students' perception and three other factors: gender, study programmes and VCE features. VCE features demonstrated the highest positive correlation to the overall students' perception, whereby visual properties appeared to be the strongest contributor to this correlation. These were supported by the obtained p-values and t-statistic values for all compared parameters in pairs, where null hypothesis was rejected, hence the data were significant from one another.

Throughout these observations, it can be concluded that the utilisation of VR technologies offers many potentials as a modern and innovative approach to T&L activities. Despite the sample size of the pilot study was still considerably small, a variety of statistical evidences consisting of Cronbach's alpha, Pearson correlation coefficient, hypothesis test, and descriptive statistics parameters such as mean and median values confirmed to support positive VR experiences of the students. Further exploration of this study would include looking at how using VR affects students' academic performance, and whether the current results on students' perception stay valid when the study is expanded to a larger size of participants. It would also be interesting to see whether tweaking the VCE features would change this perception, identifying ways on enhancing the overall student learning experience.

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A Comparison of Experienced K-12 Administrators' and Teachers' Attitude and Perception Towards One-to-one Digital Learning

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Abstract

Purpose – This study aims to investigate the attitude and perception towards one-to-one digital learning among experienced k-12 administrators and teachers, and to explore the difference in attitude and perception between these two groups.

Design/methodology/approach – Sixty-six k-12 administrators and 1,535 teachers from Guangdong province were selected as participants for this study because they had experience in one-to-one digital learning ranging from several months to years. On the basis of a literature review and an adaptation of Lindqvist's original instrument for examining superintendents' and teachers' attitude and perception towards one-to-one digital learning (Lindqvist, 2015), a survey which contained three parts was proposed. These parts were: (1) ethnographic information — sex, teaching ages, school type, grade, ICT self-efficiency, and length of experience; (2) attitude items — ever positive about the future, willingness to participate, confidence in students' attitude, and confidence in each other's attitude; and (3) perception items — impact factors of success, influence for students and teachers, and evaluation of current situation. The Cronbach's alpha values were 0.960 and 0.981, and the KMO values were 0.849 and 0.97which suggested that the instrument had good reliability and validity. SPSS22.0 was used to analyse the data.

Findings – Firstly, the results showed that experienced teachers' and administrators' attitude and perception were positively influenced by their ICT self-efficiency and length of experience. Teaching ages had a negative influence on teachers' attitude and perception, but only on administrators' perceptioon. Secondly, the administrators' attitude was more positive than that of teachers. As regards perception, there was a significant difference between the two groups. Administrators agreed on the factors that have an impact on the success of one-to-one digital learning programmes and a positive influence on students and teachers more. However, both groups agreed that the other's attitude was more positive and the current situation of their programmes was not so satisfactory.

Originality/value/implications – This study contributes to giving new insight into the attitude and perception of experienced school staff towards one-to-one digital learning. Also, useful suggestions can be extracted such as being careful about the difference, seeking common comprehension, improving ICT literacy, and being patient about the time needed for the final success of one-to-one digital learning initiatives in k-12 schools.

Keywords: experienced k-12 administrators and teachers ; one-to-one digital learning, attitude, perception, comparison study

1 Introduction

One-to-one digital learning initiatives are more and more prevailing in k-12 schools in China recent years, especially on the background of Ministry of Education's(2018) implementation of digitalized school construction and e-learning space popularization action. However, Mixue Wang etc(2017) points out that researchers pay more attention to the fundamental theory, infrastructure, educational resources, teaching models and methods, development strategies of one-to-one digital leaning nowadays. There are few studies reporting on the attitude and perception of stakeholders in one-to-one digital learning initiatives in China, especially the administrators and teachers who already have related experience. Therefore, this study will focus on investigating the attitude and perceptions of experienced primary and secondary school administrators and teachers in one-to-one digital learning classrooms, as well as their agreement on some key issues, aiming to provide some useful recommendations for the sustainable development of one-to-one digital leaning area.

2 Literature review

2.1 Definition of one-to-one digital leaning

Internationally, one-to-one digital learning is defined by Penuel(2006) who first proposed three typical features: portable laptops or other terminals equipped with productivity software, accessing to internet, helping students complete various learning tasks in schools, which is still used by many researchers in this field (Fleischer, 2012, p.108). However, there are a variety of comprehension and terminologies of one-to-one digital learning in China. It was called e-bags in early years which refer to a personalized learning environment based on the student's personal terminals, usually carrying on a large sum of electronic textbooks(Xiaohua Yu etc, 2012, p.70). As the development of new generation of information technology and education reform, more and more researchers call it smart class and have different explanations. Some researchers treat it as new classes to cultivate smart persons from education perspective(Zhiting Zhu etc, 2016, p.19) while others think it is a kind of smart learning environment based on new information technology from technology perspective (Bangqi Liu etc, 2019, p.21). No matter what it is called, one-to-one digital learning is a new kind of "student-centered" personalized learning environment where a student holds a terminal (tablet, smartphone, personal notebook, etc.) as a typical form.

As a new generation of creative learning environment, one-to-one digital learning programs have the potential to benefit teaching and learning by their features such as portability, rich resource, abundance of tools, convenience to connect network and so on(Harper & Milman, 2016, p.130). It is an ideal environment to foster student's high order thinking skills or so called "21 century skills", such as critical thinking skills, communicative skills, problem solving skills and so on(Islam & Grönlund, 2016, p.193). To sum up, this study defines the one-to-one digital learning as creative classes which are under the support of the new generation of information technology (5G, big data, artificial intelligence, internet of things, etc.), with "cloud-network-end" as the overall architecture, usually with tablets, laptops as the students' terminals, through the transformation of teaching methods by integrating technology into classroom teaching in order to construct "student-centered" digital, personalized, intelligent learning environment, so as to effectively promote students' high order thinking skills and implement the core literacy of students.

2.2 Administrators' attitude and perception towards one-to-one digital learning

School administrators are the key decision-makers and promoters of one-to-one digital learning projects. The attitude and perception of this group towards one-to-one digital learning will greatly affect the successful implementation of the projects. Cole et al.(2018) conducted interviews with managers of nine schools that already had one-to-one digital learning projects to explore the key elements that affect the successful implementation and sustainable development of one-to-one digital learning projects. They found that the key influencing factors may include the following points : school development vision, teacher professional development training, principal leadership; the effective integration of information technology and subject resources development, efficient infrastructure construction(network ,bandwidth and tablet); communicate effectively with stakeholders(teachers, students, parents, regional management departments) and so on. Simmons et al.(2016) investigated the main problems encountered by six school managers in one-to-one digital learning projects and found that goal setting and planning, teacher professional development, funding, ICT self-efficacy, attitude have a huge impact on the success of one-to-one digital learning projects. Lindqvist(2015) believes that for a one-to-one digital learning project in k-12 schools, leadership, development vision, teacher professional development, and evaluation all have important impacts on its success. When Pratt (2016)conducted a survey of administrators involved in one-to-one digital learning projects in Missouri, the United States, they believed that teacher professional development and the current developing goal establishment of the schools were the most important factors affecting the final success. To sum up, the one-to-one digital learning initiatives in k-12 schools are systematic programs which may be influenced by many aspects. And the principal care about development goal and teacher professional development especially. So, the administrators in one-to-one digital schools may not be a very tech-savvy person, but he should understand the relation between education and technology.

2.3 Teacher's attitude and perception towards one-to-one digital learning

As the important executors and implementers of one-to-one digital learning projects, teachers' attitude and perception towards one-to-one digital learning also have significant impacts on the ultimate success. Domingo et al.(2016) pointed out that the use of mobile terminals for teaching in the classroom can optimize students' learning methods, enhance learning motivation, promote autonomous learning, promote information acquisition, and promote cooperative learning. As a survey of 101 teachers pointed out that promoting information acquisition, improving learning methods and enhancing learning motivation were the greatest impacts which teachers believed that one-to-one digital learning would bring to students. Lindqvist et al.(2015) found that the factors that affect teachers' one-to-one digital learning practice included willingness to change, support from school managers, joint school management, school or national policies and teacher professional development training. Cho et al.(2016) concluded three issues that teachers were most concerned with one-to-one digital learning: classroom distraction in the short-term, classroom organization in the mid-term, and student ability development in the long-term. Pratt(2016) surveyed the views of teachers participating in the one-to-one digital learning projects in Missouri, USA and found that giving sufficient exploration time and professional development opportunities were considered important factors to ensure the success of the projects. Christensen's(2015) survey of 166 teachers who participated in one-to-one digital learning for at least one year found that 65% of teachers believed that their teaching had changed after they participated in the project. Teachers believed that the biggest challenge students facing was that students were easily distracted. In addition, it was believed that the school's information technology infrastructure, training for teachers and students, and support to all parties would greatly affect the success of the projects.

2.4 Research Questions

In summary, school administrators and teachers have similarities in their perceptions of one-to-one digital learning . For example, they both regard teacher professional development as an important factor influencing the success of one-to-one digital learning . They also have their own focuses. For example, administrators pay more attention to school goals. Teachers pay more attention to whether they can get sufficient support and participation. As one-to-one digital learning initiatives are blooming everywhere in China and there are many school administrators and teachers who already have certain experience of one-to-one digital learning , it is necessary to conduct targeted surveys of these administrators and teachers to understand their current attitude and perception towards one-to-one digital learning, aiming to refine related experience and inspire latecomers. Therefore, the research questions are: (1) What are the attitude and perception of teachers who have already experience towards one-to-one digital learning ? (2) What are the attitude and perception of school administrators who have experience towards one-to-one digital learning ? (3) Are there any differences in the attitude and perception of one-to-one digital learning among teachers and administrators who already have experience in implementing one-to-one digital learning ? What is the difference?

3 Research methodology and data collection

3.1 Research instruments

This study is based on Hakanson's questionnaire on the perception and attitude of primary and secondary school managers and teachers on one-to-one digital learning projects. The researcher consulted with relevant educational technology experts and deleted some items, finally forming this questionnaire of three main parts: ①Basic information: role, gender, teaching age, school type, school period, self-assessment of information technology level, school project sponsor, and time spent on one-to-one digital learning ; ②Attitude dimension: Whether you are optimistic about it, your willingness to participate/promote one-to-one digital learning in your school, the evaluation of the students attitude, the evaluation of the teachers or administrators attitude; ③Perception dimension: the factors that affect the success of the one-to-one digital learning(clear development goal and plan<GP>, administrators' leadership in ICT <LICT>, teacher information literacy skills <TIL>, student information literacy <SIL>, parents' support<PS>, teacher training<TT>, strong technical support <TS>, education policy guidance<PG>), the impact on students(improve students' information literacy<ISIL>, acquire more subject knowledge<SK>, more effective learning methods<LM>, promote cooperation between students<SC>, promote dialogue between students and teachers in classroom<CD>, improve communication between students and teachers<TSC>, upgrade students' academic achievement<AA>), and the impact on teachers(improve teachers' information literacy<ITIL>, improve teaching methods<TM>, acquire more effective working methods<EM>, improve cooperation between teachers<TC>, promote teacher professional development<TPD>), evaluation of the current situation of the school's one-to-one digital learning project (whether the goal is clear<GC>, the teacher training situation<TTS>, and the technical support situation<TSS>). Among them, the attitude and perception dimensions are both using the five-level Likert scale, and "1 ~ 5" respectively represent from 'strongly disagree' to 'very agree'. The Cronbach's Alpha values of the attitude dimension and the perception dimension are 0.960 and 0.981 respectively, the KMO values are 0.849 and 0.973 respectively, and the P values of Bartlett test are both 0.000, indicating that the reliability and validity of the questionnaire are good.

3.2 Data collection

The survey was distributed in the form of electronic questionnaires. The survey respondents are from k-12 teachers and school administrators in Guangdong Province, and the questionnaires for teachers and administrators are distributed separately. The survey time span is from January 1 to February 25, 2021. A total of 1537 questionnaires for teachers were returned, of which 1535 were valid questionnaires; a total of 67 questionnaires for school administrators were returned and 66 were valid. SPSS 22.0 was used for data analysis.

4 Results and discussion

4.1 Basic information of participants

As shown in Table 1, among the 1535 teachers and 66 school administrators, female teachers accounted for more than 60%, while male school administrators accounted for more than 60%. among the respondents, teachers with more than 10 or even 20 years of teaching experience accounted for more than 70%, and managers account for even more than 90%. The type of school is mainly public, with teachers and principals from public schools accounting for about 90%. The respondents are mainly elementary and junior high schools, and teachers and managers from primary school are the most, accounting for 40% to 50%. Among those whose ICT self-efficiency level exceeds the average level, the proportion of managers is higher than that of teachers, but the proportion is not more than 20%. Nearly 70% of teachers and managers think they have an average level of information technology. Most school one-to-one digital learning projects are initiated by the government or school leaders, and this proportion is more than 90% among teachers and administrators. The one-to-one digital learning projects in 1-2 years are the most, followed by projects within 3-5 years and less than 1 year, while the proportion of one-to-one digital learning projects over 5 years is less, not more than 10%.

Table1 Basic information of participants

Basics	Type	Teacher		Administrator		Basics	Type	Teacher		Administrator	
		N	%	N	%			N	%	N	%
gender	Male	558	36.4	43	65.2	ICT Self-efficiency	>average	262	17.1	17	25.8
	female	977	63.6	23	34.8		=average	1063	69.3	46	69.7
Teaching Ages (years)	0～3	166	10.8	3	4.5		>average	210	13.7	3	4.5
	3～10	240	15.6	3	4.5	Project sponsor	government	267	17.4	21	31.8
	10～20	301	19.6	17	25.8		administrators	1077	70.2	44	66.7
	>20	828	53.9	43	65.2		teachers	103	6.7	1	1.5
School types	Public	1365	88.9	60	90.9		others	88	5.7	0	0
	Private	170	11.1	6	9.1	Experience Time (years)	<1	401	26.1	17	25.8
Grade	Primary	834	54.3	31	47.0		1-2	582	37.9	23	34.8
	Middle	619	40.3	30	45.5		3-5	439	28.6	22	33.3
	High	82	5.3	5	7.6		>5	113	7.4	4	6.1

This study uses Spearman's method to test the differences in the attitude and perception of different types of experienced teachers and managers on one-to-one digital learning and use an independent sample T to test the differences in the attitude and perception of experienced teachers and managers on one-to-one digital learning.

4.2 Attitude and perception towards one-to-one digital learning of different kinds of experienced teachers

Different types of experience teachers' attitude towards one-to-one digital learning. Teachers with one-to-one digital learning experience, regardless of gender, no matter who is the initiator of the school's one-to-one digital learning project, there is no difference in their attitude towards one-to-one digital learning and their attitude tend to be conservative and optimistic. The grade of the teacher is higher, the less likely they think the principal of the school would be willing to accept the one-to-one digital learning ($p=0.016$, $r=-0.062$), while the attitude on other aspects are the same.

Among the experienced teachers, the teaching age, school type, ICT self-efficiency, and the length of time the project has been carried out will significantly affect their attitude towards one-to-one digital learning . As shown in Table 2, teachers with longer teaching years and teachers with lower ICT self-efficiency have more negative attitude towards one-to-one digital learning , which is manifested in their not so optimistic about the prospects ($p=0.00$, $r=-0.199$; $p=0.00$) , $r=-0.162$), unwilling to participate in the implementation of projects in the school ($p=0.00$, $r=-0.190$; $p=0.00$, $r=-0.155$), do not think that the school's administrators will be willing to accept one-to-one digital learning ($p=0.00$, $r=-0.204$; $p=0.00$, $r=-0.322$), don't think their students will expect one-to-one digital learning (p=0.00, r=-0.201; p=0.00, r=-0.150). The attitude of private school teachers is more positive than public school teachers in all aspects. The longer the duration of the one-to-one digital learning project, the more positive their attitude in all aspects.

Table2 Attitude and their difference between different types of experienced teachers and administrators towards one-to-one digital learning

Basics		Teaching ages		School types		ICT Self-efficiency		Experience		M	SD	Sig
		p	r	p	r	p	r	p	r			
Positive about prospects	T	.000	-.199**	.002	.078**	.000	-.162**	.000	.136**	3.87	.939	.000**
	A	.139	-.184	.183	.166	.008	-.322**	.124	.191	4.33	.810	
Willingness to carry out	T	.000	-.190**	.000	.105**	.000	-.177**	.000	.118**	3.87	.943	.000**
	A	.112	-.198	.131	.188	.041	-.252*	.238	.147	4.41	.784	
Evaluation of each other attitude	T	.000	-.204**	.000	.098**	.000	-.155**	.000	.140**	3.93	.934	.205
	A	.113	-.197	.206	.158	.068	-.226	.037	.258*	4.08	.933	
Evaluation of students' attitude	T	.000	-.201**	.000	.122**	.000	-.150**	.000	.105**	3.88	.933	.040*
	A	.149	-.179	.071	.224	.041	-.252*	.151	.179	4.12	.903	

Note: * indicates that the correlation is significant at the 0.05 level (two-tailed),
** indicates that the correlation is significant at the 0.01 level (two-tailed), the same below.
T stands for teacher, A stands for school administrator, the same as below.

Different types of experience teachers' perception towards one-to-one digital learning. Generally speaking, different types of experiential teachers have relatively large differences in perception of one-to-one digital learning. Specifically, the differences in perception of one-to-one digital learning by experienced teachers of different genders are mainly focused on the factors that affect the success of one-to-one digital learning and the impact of one-to-one digital learning on teachers. They have no different views on the impact on students and assessment of current situation. Specifically, compared with male teachers, female teachers recognize more on the impact of information-based leadership (p=0.036; r=0.053), teacher information literacy skills (p=0.027, r=0.057), and student information literacy skills (p=0.023, r=0.058), teacher training (p=0.019, r=0.060), strong technical support (p=0.042, r=0.052), education policy guidance (p=0.026, r=0.057) on one-to-one digital learning , especially the understanding and support of parents (p=0.000, r=0.089). Female teachers agreed more that one-to-one digital learning would improve teachers' information literacy and skills (p=0.042, r=0.052) and improve teachers' teaching methods (p=0.042, r=0.052) p=0.027, r=0.056), especially in promoting the professional development of teachers (p=0.004, r=0.074).

The differences on the perception of one-to-one digital learning by experienced teachers of different grades are mainly focused on the assessment of the current situation. Compared with teachers in lower grades, teachers of higher grades do not agree that the school has clear and established goals (p=0.015, r=- 0.062), has received professional teaching application training (p=0.006, r=-0.071), technical support is in place (p=0.001, r=-0.085). In addition, teachers in higher grades do not agree that one-to-one digital learning can improve student performance (p=0.011, r=-0.065) as teachers in lower grades believe. Beyond that, there is no other cognitive difference between teachers of different grades.

Who leads one-to-one digital learning projects in schools will affect teachers' perception of one-to-one digital learning in a certain extent. This is mainly reflected in the one-to-one digital learning schools led by the government or school leaders. Teachers seem to be less appreciative of the guidance of education policies (p=0.050, r=-0.050) plays an important role for the success of one-to-one digital learning and the less agree with that one-to-one digital learning will help students master more efficient learning methods (p=0.031, r=-0.055) and help teachers master more efficient working methods (p=0.021, r=-0.059) and promote the professional development of teachers (p=0.037, r=-0.053).

As shown in Table 3, experienced teachers with different teaching ages, school types, ICT self-efficiency, and project durations have significant differences in their perceptions of one-to-one digital learning, for example the success factors of one-to-one digital learning, their impact on students and teachers and the assessment of the current situation of the school's projects. Specifically, teachers with longer teaching years and lower levels of ICT self-efficiency disagree with the above four aspects. Private schools agree more than public schools in the above four aspects. Teachers who have been running the project for a longer period time are more likely to agree on the above four aspects.

Table3 Perception and their difference between different types of experienced teachers and administrators towards one-to-one digital learning

Clusters	Items		Teaching ages		School type		ICT self-efficiency		Experience time		M	SD	Sig
			p	r	*p*	r	*p*	r	*p*	r			
Factors impact success	GP	T	0.000	-	0.000	.122**	0.000	-	0.002	.078**	3.88	1.04	.002**
		A	0.302	-0.129	0.667	0.054	0.026	-0.273	0.052	0.240	4.29	1.03	
	LICT	T	0.000	-	0.000	.113**	0.000	-	0.007	.069**	3.91	1.02	.007**
		A	0.194	-0.162	0.981	0.003	0.236	-0.148	0.287	0.133	4.26	0.97	
	TIL	T	0.000	-	0.000	.121**	0.000	-	0.004	.074**	3.95	1.00	.038*
		A	0.343	-0.118	0.791	-0.033	0.680	-0.052	0.258	0.141	4.21	1.03	
	SIL	T	0.000	-	0.000	.115**	0.000	-	0.044	.051*	3.81	1.01	.513
		A	0.471	-0.090	0.470	-0.091	0.815	-0.029	0.257	0.142	3.73	1.03	
	PS	T	0.000	-	0.000	.123**	0.000	-	0.057	0.049	3.85	1.04	.262
		A	0.159	-0.175	0.780	-0.035	0.403	-0.105	0.770	0.037	4.00	1.07	
	TT	T	0.000	-	0.000	.119**	0.000	-	0.020	.059*	3.95	1.00	.003**
		A	0.670	-0.054	0.616	-0.063	0.480	0.088	0.658	0.055	4.32	0.93	
	TS	T	0.000	-	0.000	.107**	0.000	-	0.004	.073**	3.99	1.02	.000**
		A	0.438	-0.097	0.701	-0.048	0.807	-0.031	0.205	0.158	4.49	0.83	
	PG	T	0.000	-	0.000	.109**	0.000	-	0.007	.069**	3.96	1.01	.015*
		A	0.751	-0.040	0.690	0.050	0.992	-0.001	0.272	0.137	4.27	0.92	
Influence for	ISIL	T	0.000	-	0.000	.112**	0.000	-	0.007	.069**	4.00	0.94	.013*
		A	0.019	-.289*	0.053	0.240	0.125	-0.191	0.004	.351**	4.29	0.86	

students	SK	T	0.000	-	0.001	.083**	0.000	-	0.004	.074**	4.00	0.91	.004**
		A	0.015	-.297*	0.086	0.213	0.159	-0.176	0.052	0.240	4.33	0.87	
	LM	T	0.000	-	0.000	.091**	0.000	-	0.005	.072**	3.99	0.93	.010**
		A	0.155	-0.177	0.175	0.169	0.223	-0.152	0.031	.265*	4.29	0.92	
	SC	T	0.000	-	0.001	.084**	0.000	-	0.008	.067**	3.97	0.93	.006**
		A	0.097	-0.206	0.159	0.175	0.265	-0.139	0.182	0.166	4.29	0.91	
	CD	T	0.000	-	0.000	.096**	0.000	-	0.000	.091**	3.98	0.93	.016*
		A	0.032	-.264*	0.053	0.240	0.092	-0.209	0.158	0.176	4.26	0.92	
	TSC	T	0.000	-	0.001	.088**	0.000	-	0.000	.091**	3.97	0.93	.007*
		A	0.108	-0.200	0.464	0.092	0.237	-0.147	0.044	.248*	4.29	0.89	
	AA	T	0.000	-	0.000	.092**	0.000	-	0.002	.081**	3.92	0.93	.011*
		A	0.544	-0.076	0.315	0.126	0.213	-0.155	0.081	0.217	4.21	0.87	
Influence for teachers	ITIL	T	0.000	-	0.000	.110**	0.000	-	0.002	.080**	4.06	0.89	.002*
		A	0.369	-0.112	0.119	0.194	0.180	-0.167	0.055	0.237	4.41	0.82	
	TM	T	0.000	-	0.000	.114**	0.000	-	0.002	.077**	4.02	0.91	.001**
		A	0.057	-0.235	0.297	0.130	0.121	-0.193	0.017	.292*	4.41	0.88	
	EM	T	0.000	-	0.000	.099**	0.000	-	0.003	.077**	4.02	0.92	.001**
		A	0.011	-.310*	0.231	0.149	0.067	-0.227	0.095	0.207	4.39	0.84	
	TC	T	0.000	-	0.000	.108**	0.000	-	0.002	.078**	3.99	0.92	.057
		A	0.013	-.305*	0.111	0.198	0.145	-0.181	0.031	.266*	4.21	0.95	
	TPD	T	0.000	-	0.000	.097**	0.000	-	0.002	.078**	4.05	0.91	.012*
		A	0.167	-0.172	0.074	0.221	0.201	-0.159	0.150	0.179	4.33	0.85	
Evaluation of current state	GC	T	0.000	-	0.001	.081**	0.000	-	0.000	.147**	3.77	0.94	.017*
		A	0.396	-0.106	0.141	0.183	0.029	-0.268	0.354	0.116	4.03	0.84	
	TTS	T	0.000	-	0.004	.074**	0.000	-	0.000	.171**	3.66	0.98	.748
		A	0.882	0.019	0.077	0.220	0.177	-0.168	0.028	.270*	3.70	0.98	
	TSS	T	0.000	-	0.000	.091**	0.000	-	0.000	.169**	3.63	1.00	.416
		A	0.089	-0.211	0.104	0.202	0.104	-0.202	0.063	0.230	3.73	0.97	

4.3 Attitude and perception towards one-to-one digital learning of different kinds of experienced administrators

Different types of experience administrators' attitude towards one-to-one digital learning. Among the experienced administrators, gender, teaching age, school type, grade, and who sponsor the one-to-one digital learning project will not affect their attitude towards one-to-one digital learning and they are generally active. However, school administrators with different ICT self-efficiency have different attitude towards one-to-one digital learning. School managers with lower ICT self-efficiency are less optimistic about the prospects of one-to-one digital learning (p=0.008; r=-0.322), unwilling to promote the one-to-one digital learning project (p=0.041; r=-0.252), the less likely they think that students will look forward to the one-to-one digital learning (p=0.041; r=-0.252); the school administrators who undertake the one-to-one digital learning project longer are more positive when they evaluate teachers' attitude towards one-to-one digital learning(p=0.037; r=0.258).

Different types of experience administrators' perception towards one-to-one digital learning. Managers of different genders, school types, and grades have no differences in their views on one-to-one digital learning. Different teaching ages, ICT self-efficiency, one-to-one digital learning sponsors, and project duration have a greater impact on the perception of experienced administrators towards one-to-one digital learning. As shown in Table 3, specifically, school administrators with older teaching years do not think that one-to-one digital learning projects can help teachers master more efficient working methods (p=0.011, r=-0.310) and promote cooperation between teachers (p=0.013, r=-0.305), the other parts of the view are the same. The lower ICT self-efficiency, the less administrators think that clear school development goals and plans will affect the successful implementation of one-to-one digital learning projects in schools (p=0.026 , R=-0.273) and do not think that the school's one-to-one digital learning initiatives has established very clear goals (p=0.029, r=-0.268), the other parts of the view are the same. The managers in the one-to-one digital learning projects initiated by the grassroots recognize more about that one-to-one digital learning can promote cooperation between students (p=0.022, p=0.282), improve dialogue between teachers and students in class (p=0.010, r=0.316) and promote cooperation between teachers (p=0.036, r=0.259), the other parts of the view are the same. The longer the administrators implement the one-to-one digital learning projects, the more they recognized that one-to-one digital learning will improve students' information literacy and skills (p=0.004, r=0.351) and help students master more efficient learning methods (p=0.031 , R=0.265), improve the contact and communication between teachers and students (p=0.044, r=0.248), promote cooperation between teachers (p=0.031, r=0.266), and recognize that the school has accepted more professional teaching training (p=0.028, r=0.270). The other parts of the perception are the same.

4.4 The comparison of attitude and perception between the two groups

The comparison of attitude between the two groups. School administrators and teachers who have experience in one-to-one digital learning have different attitude toward one-to-one digital learning. Teachers' attitude toward one-to-one digital learning (M=3.87, SD=0.939; M=3.87, SD=0.943) is slightly negative than the attitude of school administrators (M=4.33, SD=0.810; M=4.41, SD=0.784). As shown in Table 2, especially when it comes to whether they are optimistic about the prospects of one-to-one digital learning and whether they are willing to participate or promote the one-to-one digital learning projects, the sig value is both 0.00, which show that the attitude difference between the two groups is very significant. When assessing the students' expectation of the one-to-one digital learning project, the sig value is 0.040 which show that there is a significant difference and the teachers' attitude (M=3.88, SD=0.933) is slightly more negative than the attitude of administrators (M=4.12, SD=0.903). However, it is interesting that there is no significant difference between the two groups in assessing whether the other party's attitude towards the one-to-one digital learning is positive and both they believe that the other party will be more positive.

The comparison of perception between the two groups. There is a big difference between school administrators and teachers' perception towards one-to-one digital learning. School administrators are more positive than teachers in most parts of perception while keep consistent in less parts. Specifically, as shown in Table 3, in terms of the main factors affecting the success of one-to-one digital learning , there are significant differences in perception between the two groups. In terms of clear goals and planning, ICT leadership, pedagogical training, and strong technical support and guarantees, although both they believe that they are the most important factors influencing the success of one-to-one digital learning , it is obvious that school administrators pay more attention to these factors. There are also certain differences in teacher information literacy and skills, and education policy guidance between the two groups and it is also the school administrators who pay more attention to these factors. But in the two aspects of student information literacy and skills and parents' understanding and support, the two groups' views tend to be consistent. Compared with other factors, it is not the most important factor and even managers think the importance of students' information literacy and skills (The evaluation of M=3.73, SD=1.03) is slightly lower than that of the teacher (M=3.81, SD=1.01).

In terms of the possible impacts of one-to-one digital learning on students, there is a big difference between the perception of school administrators and teachers. In general, administrators recognize the many beneficial effects that one-to-one digital learning may bring to students more than teachers, especially on helping students master more subject knowledge, mastering efficient learning methods and promoting cooperation between students.

In terms of the possible impact of one-to-one digital learning on teachers, the cognitive differences between school administrators and teachers are mainly to improve teachers' information literacy and skills, improve teachers' working methods, help teachers master efficient working methods and promote teacher professional development. Among above four aspects, especially the first three aspects, managers are more affirmed. Administrators and teachers have no differences in the perception that one-to-one digital learning can promote cooperation between teachers (sig=0.57).

In assessing the current situation of the school's one-to-one digital learning, the school administrators and teachers have relatively small differences and they both do not agree that the school's teachers have received enough professional teaching application training (M=3.66, SD=0.98; M=3.70, SD=0.98) and sufficient technology guarantee (M=3.63, SD=1.0; M=3.73, SD=0.97). In addition, in assessing whether the established goals of the one-to-one digital learning in their school are clear, the perceptions of the two groups are not consistent and administrators (M=4.03, SD=0.84) are obviously more active than teachers (M=3.77, SD=0.94).

5 Conclusion and suggestions

Generally speaking, in terms of attitude towards one-to-one digital learning, experienced teachers are more conservative than experienced administrators. In terms of prospects for future, willingness to participate and evaluation of students' and teachers' attitude about future, teachers are not so optimistic as administrators. In terms of perception of one-to-one digital learning, there is a big difference between the two groups. It is mainly reflected on three aspects which are factors affecting the success of one-to-one digital learning, the impact of one-to-one digital learning on students and teachers. Administrators are more affirmed about above three aspects.

5.1 Differences are obvious between two groups, requiring common ground while reserving differences.

Compared with the group of administrators, experienced teachers have a greater difference among different types in their perceptions towards one-to-one digital learning. For example, administrators' perception and attitude towards one-to-one digital learning will not be affected by gender, grade, and school type, but teachers will be affected by these three factors. However, administrators and teachers also have similar attitude and perception on some aspects. For example, they both think that the other side's attitude towards one-to-one digital learning is relatively more positive. They have relatively consistent assessments of the current implementation situation of one-to-one digital learning projects in their schools, for example the status of teacher training and technical support which they are not so satisfactory. They both think that students' information literacy and skills are not the main factors affecting the ultimate success of one-to-one digital learning and one-to-one digital learning can promote cooperation between teachers. In addition, whether teachers or managers, teaching age, ICT self-efficiency and project duration are important factors that affect their perception. In general, school administrators have more positive attitude and perception towards one-to-one digital learning. For example, they recognize the importance of goals for the school's one-to-one digital learning projects. In fact, they also believe that their school's goals are clearer.

In the case that most of the one-to-one digital learning projects are promoted by administrative orders and initiated from the top to the down, teachers do not recognize the important role of education policies in one-to-one digital learning and the beneficial effects that one-to-one digital learning may bring to teachers and students. Therefore, administrators need to influence teachers with their own passion and self-confidence continually. On the consensus that has been reached, administrators and teachers should strengthen communication, continue to expand consensus, seek common ground while reserving differences and seek common development.

5.2 Improving the level of information technology is the key.

Research has found that experienced administrators with low ICT self-efficiency have less positive attitude towards all aspects of one-to-one digital learning and they do not value the importance of goals and do not think their own schools have clearer goals at the same time. In the same way, experienced teachers with a low ICT self-efficiency are not positive as well. They neither recognize the important factors that affect the success of one-to-one digital learning nor recognize the positive impacts of one-to-one digital learning on teachers and students and their evaluation of their school projects is lower. Therefore, both administrators and teachers should actively improve their own information technology level. Their confidence of ICT will greatly affect their own attitude and perception towards one-to-one digital learning and the ultimate success of the project.

5.3 While promoting one-to-one digital learning projects continually, time is an important variable.

Among the teachers and administrators who have carried out the one-to-one digital learning projects, the longer the implementation time, the more positive their attitude towards all aspects of the one-to-one digital learning. And the longer the implementation time, the more experienced teachers and administrators affirm the positive impact of one-to-one digital learning for students and teachers. The longer the implementation time, the major impacts of the school are more recognized by experienced teachers and the more school's teacher application training experienced are affirmed by experienced administrators. Therefore, time is an important variable in the one-to-one digital learning projects. There will be many difficulties when starting the one-to-one digital learning project, especially the "second year phenomenon", that is, participants may feel that the goal is not reached, teaching and learning effectiveness are significantly reduced, and confidence is insufficient in the second year of the one-to-one digital learning project(Swallow, 2015, p.122). However, facts have proved that the longer the time, the more experience the school staff will acquire. And their attitude and perception of one-to-one digital learning will become more and more positive.

5.4 There are huge differences between different entities of one-to-one digital learning , requiring individualized strategies.

Research has found that female experience teachers are more certain than male teachers in most of their perception towards one-to-one digital learning . Among teachers who have experience in one-to-one digital learning , the older their teaching age, the more negative their attitude towards one-to-one digital learning will be and the more negative their perception of various aspects of the one-to-one digital learning will be. Among the administrators who have experience in one-to-one digital learning , the teaching age will not affect their attitude towards one-to-one digital learning. But the older the administrators, the less likely that they will agree that one-to-one digital learning can improve teachers' working methods and promote cooperation between teachers. Private schools are obviously more active in their attitude and perception of one-to-one digital learning than experienced teachers in public schools. Compared with teachers in the lower grades, teachers in the higher grades are obviously more dissatisfied with the current situation of the school's one-to-one digital learning projects. They do not think the school's administrators will be willing to promote one-to-one digital learning , nor do they believe that one-to-one digital learning have a greater impact on student performance. It can be seen clearly that in the process of promoting the sustainable development of one-to-one digital learning, we should always pay attention to the differences of the implementation entity, for example adopting policies based on different groups and driving disadvantaged groups by advanced groups.

6 Limitation

K12 administrators and teachers who already have experience self-report their attitude and perception about one-to-one digital learning projects. The results may be influenced by unrelated factors, for example the physical situation, emotional state or others' ideas and so on. In the future, more class observation, interviews with school staff can be done to explore the relation between their attitude and perception and practical practice. Additionally, the results can just imply situation of GuangDong province because of the selection of participants.

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Podcasts as Metacognitive Prompts: A Case Study of Graduate Students' Metacognition Regarding Citations

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Abstract

Purpose – The purpose of this study is to explore the potential for 'integrated' podcasts to act as metacognitive prompts that might stimulate graduate education students to reflect on the nature and purpose of citing and citations, and on their metacognitive knowledge of the cognitive strategies they employed when using citations for academic purposes.

Design/methodology/approach – A qualitative, interpretivist stance was adopted for this study. Two full professors in an education faculty were interviewed regarding their understanding of the nature and purpose of citing and citations, and the cognitive strategies they employed when using citations for academic purposes. These interviews were edited into two separate audio-podcast episodes and made available to students in a graduate-level education research methodology course via the University's online platform. Four students in a class of 15 consented and participated fully in the study, engaging with the podcasts. Their knowledge of the nature and purpose of citing and citations, and the cognitive processes they employed when using citations, were explored pre- and post-engagement with the podcasts, using questionnaires and semi-structured interviews. Comparisons between individual students' pre- and post-self-reports were investigated, and thematic analysis was undertaken for the whole corpus of data.

Findings – Students reported that the content of the podcasts prompted them to reflect consciously on their understanding of the nature and purpose of citing and citations, and the cognitive strategies they employed when using citations. The podcasts acted as metacognitive prompts, as intended. They reported that each of the professors' views was informative, noting also the similarities and variations between the professors' metacognitive knowledge and their own. Students variously reported changes to their cognition as a consequence of engagement with the podcasts.

Originality/value/implications – The potential of podcasts for targeting specific cognitive strategies and the metacognition related to that cognition are underexplored. Given the popularity, ease of production, and accessibility to podcasts, the potential for such use in higher education is demonstrated through this study. Future research into the use of podcasts for targeting other specific academically-oriented cognition and metacognition is proposed.

Keywords: podcasts, metacognition, cognitive strategies, academic citations.

1 Literature and Study Objectives

This paper addresses the potential of a specific form of technology, the podcast, and its content, to engage students in higher education to reflect on their metacognition regarding cognitive processes that are essential for academic achievement. We define metacognition as the knowledge, control, and awareness that an individual has of their thinking and learning processes. This definition resonates with the principles of Flavell (1979), Schraw and Moshman (1995), and Thomas (2012). The importance of metacognition for learning across all subject areas is today accepted widely, with Hattie (2009), stating that the teaching and students' use of metacognitive strategies was a significant influence on student achievement with a mean effect size of 0.67. Our position is that metacognition is germane to any form of conscious cognitive endeavour that individuals might engage in. While acknowledging that an individual's are not aware or conscious of much of their everyday thinking (Kahneman, 2011) we are of the view that instruction for metacognition should be explicit and that students should be aware of teachers' instructional goals for their cognition (e.g., Schraw, 1998, 2001) Further, we propose that it is valuable to explore context-valued cognitive strategies that students should employ in their academic work rather than isolated skills that might be more generic in their nature. In this paper we explore the potential for integrated podcasts (Drew, 2017) and their content to act as metacognitive prompts to engage graduate university students to revise their metacognition related to the cognitive strategies of citing and citation use.

Citing and citation use are important elements of university scholarship. However, these practices are often reported as problematic for students in higher education settings (e.g., Childers & Bruton, 2016; Flaspohler, Rux, & Flaspohler, 2007; Kargbo, 2010). Two elements of citing and citation use are evident. The first relates to the mechanics of citations. This involves understanding how to accurately refer to another author and their work in-text, and how to create an accurate and complete reference list. This can involve learning about the conventions and algorithmic mechanisms of, for example, the Harvard or APA referencing systems. Typically, much of the teaching about citing and citation use at universities relates to this element of citing procedures. Also, instruction related to this element is typically undertaken by librarians and writing centres at universities. The second element of citing and citation use, and the type relevant to this study, involves and requires higher-order thinking. In this element a considerable amount of intra-personal self-talk is required of an individual to ascertain the appropriate use of another's ideas, how best to represent them in one's work, and how to ensure that the intended use and meaning of one's work accurately reflects the intentions of the author/s one is citing or quoting. The cognition associated with this element is clearly beyond the predominantly algorithmic thinking related to using a prescribed referencing system. However, most research work regarding citation use and citing is related to academic honesty and plagiarism and there are few, if any studies that attend to the elements of citing and citation use that we have outlined, especially related to the second element requiring the higher-order thinking, that we have described above. In this study, we sought to explore, understand, and inform students' metacognition regarding citing and citation use that involves high-order thinking.

As previously detailed, metacognition refers to an individual's knowledge, control, and awareness of their thinking and learning processes. Metacognitive knowledge can be categorized as declarative, procedural, and conditional (Carrell, Gajdusek, & Wise, 1998; Schraw, 1998; Thomas, 2012). Declarative metacognitive knowledge is that knowledge related to facts, theories, beliefs and opinions about thinking and learning. Procedural metacognitive knowledge refers to an individual's knowledge of how to perform cognitive activities. Conditional metacognitive knowledge refers to knowing when and why to employ particular cognitive processes to achieve one's cognitive goals and why it is appropriate to do so. All students are metacognitive to some extent (Gunstone & Mitchell, 1998), that is, all students have some knowledge, control, and awareness of their thinking and learning processes. However, as an individual moves from one learning environment to another, e.g., from high school to university, or from undergraduate study to graduate study, the expectations for learning and related cognitive demands change. This means that the form or level of thinking that was appropriate for one environment might not be appropriate or adaptive for a new environment. Regarding the cognitive processes involved in citing and citation use, it is expected that individuals understanding and use of such these academic processes will necessarily develop as they move through high school to and through undergraduate study, and then to graduate work if that is their educational progression. Therefore, one expects their cognition regarding citing and citation use to become more sophisticated and also expects that their metacognition would also develop in response to the changing demands of their learning environments.

In this paper we adopt the view proposed by Vygotsky (1978, 1987) that the development of expertise related to a particular form of cognition can be effected when a less-expert novice is placed in an environment with a more-expert individual. When the novice engages with the cognition of the more-expert, the novice can come to understand that cognition and self-speech being modelled or explained to them by the more-expert. We can say that being in the same environment and having the cognition modelled or explained to them can act as a metacognitive prompt for the novice to consider new and possibly alternative ways to consider ideas and the cognition that relates to or that guides the formation of those ideas.

The notion of 'prompting' is well established in the metacognition literature (e.g., Engelmann, Bannert, & Melzner, 2021; Rayne *et al.,* 2004; Schraw, 2001) where the use of metacognitive prompts are commonly reported on. A metacognitive prompt is a signal to students to attend to and reflect on the cognition they employ when performing specific learning or thinking tasks. Therefore, in the novice-expert relationship referred to above, a metacognitive prompt can be planned when the novice is situated in an environment where they can engage with the ideas of the more-expert that are related to the more-expert's cognition. In such a situation the more-expert is required to make their cognition explicit so the novice might assess the intelligibility and plausibility of the more-expert cognition. In the case of the cognition related to citing and citation use this would involve the more-expert articulating the cognition they employ in such a manner that the novice can make those assessments and decisions. From there the novice can decide whether they are dissatisfied sufficiently with their extant cognition to possibly trial and adopt, possibly with adaptations, the more-expert cognition into their cognitive repertoire.

The environments within which prompts are embedded need not be in-person or synchronous; they can be virtual and asynchronous. In our study we considered that using podcasts might be a viable means to create an asynchronous learning environment where the novice could engage with the explicit intimations of the more-expert to make those determinations. Podcasts have been growing in popularity since the name entered everyday vernacular in around 2004 (Peoples & Tilley, 2011). Podcasts are audio (mp3) or video (mp4) files that are made available for download over the Internet. Podcasts can be downloaded and played on multiple devices, including those that are portable such as mobile phones. Their distribution and playing is often enabled through free players, and free or low-cost providers. Their form of distribution and accessibility make them ideal for asynchronous information transfer that can be contemplated by listeners when they consider they have the time and impetus to do so. In our study we employed what Drew (2017) describes as an "integrated" podcast in which "unique content such as guest interviews, podcast-only lessons and roundtable discussions" (p. 51) were created and shared with students. It is our understanding that podcasts have not been employed as information conduits to target the metacognition of students in relation to specific cognitive processes, even though Kirschner and Popova proposed that podcasts might be used to prompt students to "reflect on what they are studying, and what they learn," to "take on the perspective of others," and "affect metacognitive processes" (2007. p. 3).

In our study we created two podcast episodes in which two full professors provided information on the cognition they employed in relation to citing and citation use. Our goal was to prompt students to consider their own cognition related to these crucial academic processes, and to decide if they should trial and to adopt the cognition intimated to them by the professors in the podcast episodes.

2 Methodology; Justification and Limitations

We adopted a qualitative, interpretive stance for this study as we were interested in the actions and experiences of individuals that were "locally distinct and situationally contingent" (Erickson, 1998, p. 1155). The study represents an instrumental case study (Stake, 1994, p. 237), in which a "particular case," a selection of graduate education students, "is examined to provide insight into an issue," the use of podcast episodes as metacognitive prompts to engage the students with the intimations of full professors regarding the cognition they employed in relation to citing and citation use.

The first author interviewed two Full Professors, Kevin and Bridgette (pseudonyms) from within the Education Faculty the first author is a member of. The interviews were recorded into GARAGEBAND™ using an AUDIO-TECHNICA™ AT2050 Multi-Pattern microphone and a Behringer U-Phoria UMC22 2x2 USB audio interface. Both professors gave written and oral consent to be interviewed and to have their interviews made into podcast episodes. In these interviews Kevin and Bridgette were asked a series of questions that were identical to those that were asked of the participating students in the questionnaires and interviews they completed. These questions can be found in Appendix A. The interviews took on a conversational format and where appropriate the professors were asked to elaborate, to story, their answers to provide potential vicarious experiences for the students regarding the cognition they employed in citing and citation use. They checked and approved the final edits of the episodes. Kevin's episode was 32 minutes, 48 seconds in length, while Bridgette's was 14 minutes, 51 seconds in length.

The instructor of a graduate class studying research methodology in the Education Faculty was approached and gave permission for the authors to visit the class to seek students' consent to participate in the study. Four students of the fourteen students present at the first class of the course, when the visit of the authors occurred, consented to participate. These four students participated in all data collection activities and engaged with both episodes of the podcast. These four students form a convenience sample. In table 1 their names (pseudonyms), programmes, and years in that programme are outlined. Students taking the course were from both PhD and Masters of Education (MEd) programmes and in Table one we give an indication of the percentage of the coursework each student had completed for their programmes. Both the PhD and MEd programmes require 10 courses to be completed.

The pre- and post-intervention assessment of the students' metacognition in relation to citing and citation use involved both questionnaires and interviews. The students completed the questionnaires that, as mentioned before, contained the same questions as those asked of the two professors. They were interviewed regarding their responses and both the interviews and the questionnaires were used to construct profiles of each students' metacognition regarding citing and citation use. Following the pre-intervention data collection which was completed in the third week of term, all students in the class, including those who were not participating in the study, were given access to the two podcast episodes that were housed on the university's secure, password-protected server. In the last two weeks of the thirteen-week course the participating students completed questionnaires that asked the same questions as the first questionnaire, and also asked them to consider any changes to their initial pre-intervention responses. Interviews were again conducted to explore students' responses to the second questionnaire. The students' self-reports constitute the data for this study.

In seeking to identify changes to the students' metacognition, we used the framework for metacognition previously described as the basis for analysis. In other words, we sought to identify any changes to the participants' self-reports of their knowledge, control, and awareness of their thinking processes related to citing and citation use. Changes to any element of a student's metacognition constitute a change to their metacognition. Also, a change in any of metacognitive knowledge components declarative, procedural, or conditional, constitutes a change in the metacognitive knowledge element and, consequently, a change in an individual's metacognition. For example, a change in declarative metacognitive knowledge could be evidenced by a change in a student's understanding of the nature or role of citations in their academic work and writing. A change in procedural metacognitive knowledge could be evidenced, for example, by a change in a student's knowledge of what processes and procedures are involved in citing. A change in conditional metacognitive knowledge could be evidenced by, for example, a change in when or why it is appropriate to engage either their prior or new declarative and/or procedural metacognitive knowledge. Changes in awareness are evidenced by self-reports of students explicating their active use of their new metacognitive knowledge, or a renewed awareness of the efficacy or value of their pre-existing cognition and processes. Changes in control are evidenced, for example, by students' self-reports of them employing their conditional metacognitive knowledge. Given the qualitative, interpretivist stance of our study, we did not seek to quantify any changes to the students' metacognition that we identified. In what follows we identify any changes to the students' metacognition and use their own words to describe those changes and their thoughts on their experiences with the podcast episodes.

3 Data and Findings

In this section we provide data in two forms. Firstly, Table 1 identifies any elements of the students' metacognition related to citing and citations that changed as a consequence of their engagement with the podcast episodes. It provides a summary view of the changes for each of the students. Secondly, we provide three assertions in which we provide examples, using the students' own words, on the nature of any changes to their metacognition that we identified. The data reported reflect changes pre- to post-intervention to the students' metacognition that they specifically and clearly attributed to their engagement with the podcast episodes.

Table 1
Summary of changes to students' metacognition

Student	Programme	Courses completed	Metacognition Change				
			Knowledge			Awareness	Control
			Dec.	Pro.	Cond.		
Arlo	MEd	50%	✓			✓	
Aria	MEd	30%				✓	
Tanner	MEd	80%	✓	✓	✓	✓	
Quenta	PhD	80%	✓	✓	✓	✓	✓

Assertion 1: All students developed a metacognitive awareness of the extent to which their cognition related to citing and citation use was similar or different to that of the two professors.

This metacognitive awareness development was a consequence of them consciously comparing their existing metacognition with that of the professors that was outlined in the podcast episodes. The following quotes from Arlo and Aria exemplify this process of reflection.

> It was very good to learn what the professors said they do. Their process of it was, I thought, very helpful, because we look up to those professors and their work and we read it in class, and its impressive. It's nice to hear how they go through other articles and pull out information for their own work. I think it was Kevin who talked a little more to that. It's not the same method that I'd use, but it's nice to hear the way professionals do it. That really stood out. (Arlo)

I haven't heard someone talk through their thinking processes like that before. It is helpful to hear, more in a direct way, that the way someone else is thinking about it [citing and citation use] is similar to how I think about it. They will be more experienced and advanced, and they've had more experience with that [citing and citation use] than I've had. I am on the right track. There's obviously things I can always be improving, but I'm on the right track. (Aria)

Assertion 2: Some students identified changes to their metacognitive knowledge related to citing and citation use.

Not all students reported the changes to their metacognitive knowledge, Aria reported no changes, suggesting, as noted in Assertion 1, a similarity between her cognition and that of the professors. There was variation between students regarding the changes they reported in their metacognitive knowledge. In relation to his declarative metacognitive knowledge, Arlo, for example, reported:

Something that was brought up in the podcast is the idea of understanding the meaning behind what the writer is trying to get across in their work. So, instead of having just those little snippets of citations, it's that broader understanding of what they're going for and then you're able to use their work to help your own. What we want is the author's intent…you have to understand the general philosophy of the person you are citing in order to truly help your work instead of just dropping quotes all over the place."

In relation to changes in procedural metacognitive knowledge, students were able to compare their previous knowledge with what they had constructed through their engagement with the podcast episodes. For example, Tanner was not sure if, in his past work, he had been "genuinely representing the ideas that were presented" in the research he was citing. He suggested,

…it was not something I had done in the past, and I definitely think we tend to 'cherry pick' what we want, and in doing so we run the risk of misrepresenting the research that was done to force it to fit our own desires as opposed to staying very focused on what the author originally was intending to say.

Quenta reported substantial changes to her procedural metacognitive knowledge, as exemplified in her own words:

The way I do citing and citations is now different to before. Before, I cited some words just because those words were what I wanted to say but the author expressed it in such a beautiful way that I wanted to cite them as evidence. Now I've come to see that I must comprehend the author's intent and meanings fully and think more deeply about how the author's words could be systematically integrated or incorporated into my own writing, and then I can cite them to support my own views. Now I find that I think more carefully, deeply about whether or how I can incorporate this [author's

> writing] into my paper. I now ask myself questions, a kind of self-communicate process. Questions like: "Are the author's ideas and views consistent with my ideas and views? Am I privileging my views over others? Am I purposely evading some opposite or antithetical views in order to persuade the readers to agree with my views?" I never asked these self-communication questions before.

Both Tanner and Quenta reported changes to their conditional metacognitive knowledge that were consistent with the changes they reported to their procedural metacognitive knowledge. Tanner, in outlining why it is important to cite differently to how he had before suggested,

> If I'm properly citing an author that has gone through the rigor required to be published it can add credibility to what I'm saying. It almost substantiates what I'm saying so that my ideas don't appear to exist in a vacuum. I'm using credited research and in doing so I'm adding credibility to the opinion I'm trying to convey."

Quenta also suggested that it was important to engage the new procedural knowledge she had developed. When asked why, she stated it was to show "readers that I am acquainted with the field I'm working in," and that she would ask herself, "Would readers think that I am very familiar with the field I am working in after they read my article?" Her motive was, "to persuade readers to believe that I'm saying is convincing."

Assertion 3: The impact of the information in the podcast episodes influenced the metacognition of the students and its engagement to varying extents.

As is reported in Table 1, the impact of the information in the podcast episodes had varying influences on the metacognition of the students. For Arlo, Aria, and Tanner, the podcasts predominantly affirmed their existing metacognitive knowledge and cognition regarding citing and citation use. For example, Arlo suggested the main impact of the podcasts was to get him to consider how he could "further develop the way" he might "think in a different way" about "rolling" the new ideas into his own existing methods. When asked if his processed had changed he replied, "No. They remain the same, as they have worked for me to this point." While Tanner reported changes to all elements of his metacognitive knowledge, he did not report engaging that knowledge into his practices, even when asked several times in the post-intervention interview. However, Quenta reported substantial changes to her cognition related to and consistent with the changes to her metacognitive knowledge. Her motivation, as can be inferred from the changes reported to her conditional knowledge, was to convince or persuade readers as to her familiarity with the field she was working in and to support her claims.

4 Discussion & Implications

Our findings suggest that the information in the podcasts served as metacognitive prompts that engaged students in consideration of their cognition related to the citations and their citation practices; albeit to varying extents. As in many studies in the field of metacognition there are considerable variations evident regarding the impact of interventions on students' metacognition. This variation is clearly apparent in Table 1. We expect this variation to be evident as students each have had different experiences in their academic lives that will, by implication, mean that they have constructed varying metacognition related to any given cognitive process. Students clearly identified that it was the content of the podcast episodes that prompted and facilitated their engagement. While Quenta seemed to be most influenced by what she learned from the episodes and her metacognition change was more extensive than her three classmates, the classmates also benefitted from the information they accessed. There is value for one's metacognition even if it is only in becoming aware that one's cognition is similar to that which a more-expert in the field of study one shares with them. If nothing else, this can reassure individuals and elevate their self-confidence regarding the thinking they employ to try to meet their academic goals. In the case of Arlo, while he reported changes to his metacognitive knowledge, he did not report changes to any of the actual processes he employed. This lack of implementation of newly acquired metacognitive knowledge, and the reasons behind it were not explored in this study, but are worthy of further investigation. Further, we found it surprising that Quenta, a PhD student, was less metacognitively knowledgeable about the higher-order thinking that should be engaged in citing and citation use than the other three students who were in their Masters programmes. This again highlights to us the variation in metacognition that students can present with in relation to any cognition, and how we should not assume that students at any level of study possess the requisite higher-order thinking necessary for success.

In this study we have focused on particular cognition that is relevant to academic and scholarly life and that graduate students, from our review of the literature, receive little if any formal training in, especially related to the higher-order cognition identified by the students. We propose that podcasts could be used to create virtual, asynchronous learning environments where novice or even experienced students and scholars could engage vicariously with the cognition and learning processes of those who work in similar fields and who are leaders in those fields. Providing the appropriate scaffolds to prompt individuals to consider their own cognition in comparison to that of more-experts is important. This is because there is a need, in our view, to structure the intrapersonal dialogue the novice or less-expert has with themselves regarding the variations they might detect between their views and those of the more-expert as suggested by Vygotsky (1978, 1987) and Sfard (2008).

We propose that podcasts could provide an easy to learn, easy to use means of developing asynchronous learning environments where students in all subject areas of higher education (and maybe pre-higher education) could engage with explorations of the cognitive processes of those more-expert in their fields of interest and develop their metacognition that is adaptive for the progress and success. At the same time, we acknowledge the following limitations of our study. Firstly, the generalizability of our findings is limited due to the small convenience sample. A larger sample size would have enabled us to provide more detail and seek more consensus finings that would strengthen the generalizability of the findings. The generalizability is also limited by the nature of that convenience sample; all graduate education students. Sampling from across courses and subject areas would improve the generalizability of any findings. Secondly, we have no delayed data collection and all data collection was completed within two weeks of the course completion. It would be important to know if the impact of the learnings from the podcast episodes persist over time, in other subjects, and to what extent. Finally, our study relies on students' self-reports of their metacognition related to citing and citation use. Self-reports on metacognition constitute data collected though off-line means (Saraç, & Karakelle, 2012). Such means have been criticized by authors such as Veenman (2011) as being unreliable. However, their use is supported by Saraç, & Karakelle, 2012 and Thomas (2012) who argue that the use of off-line methods has led to valuable insights regarding cognition and metacognition.

5 Future Research

There is a need for exploring means of communicating explicitly with learners about the cognition required to learn the material in their fields and the cognitive skills and processes that are both general and specific to their fields. The findings from our exploratory study suggest that podcasts might be one way to engage in such explicit communication about such matters. For this proposition to be explored further will require that researchers clearly identify the intrapersonal language and communication that is associated with specific cognitive processes so that it can be the basis for podcast content. Research employing larger sample sizes and perhaps using quantitative metrics will be necessary to confirm or disconfirm the findings of this study and provide a platform for future research.

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Appendix A

Questionnaire 1.

1. Have you ever done citing/citations before? (Yes/No)
2. How do you define what it means to cite?
3. How would you define the word ‘citation’?
4. Why do you think students/scholars (et al) at universities do citing/citations?
5. Do you think crediting ideas from materials to the people who wrote them is important?
6. Please describe your past experiences with citing/citations.
   Would you describe those experiences as positive, negative, or somewhere in between? Explain.
7. What makes a citation a ‘good’ citation?
8. When do you think it is appropriate to engage in citing and using citations?
9. Please explain the thinking processes/strategies you use (or have used in the past) to do citing/citations, as you understand them at this point in time.
10. Who do you refer to when you are looking for answers to citation questions?
11. How did you learn to do citing/citations? Are there any specific people or incidents that come to mind?
12. Do you have struggles/difficulties with citing/citations? How do you think you might overcome those struggles/difficulties?
13. What do you think the role of the library is in relation to enhancing your knowledge of and processes of citing/citations?
14. What do you think the role of the library could be in relation to enhancing your knowledge of and processes of citing/citations?
15. What do you think the role of your course instructors could be in relation to enhancing your knowledge of and processes of citing/citations?
16. Have you ever been asked questions such as this in relation to citing/citations before?
17. Are there any other comments or ideas you would like to share about your responses to the items on this questionnaire?

Will I Continue Teaching Sustainable Development Online? An International Study of Teachers' Experiences During the COVID-19 Pandemic

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Abstract

Purpose – K-12 education has undergone drastic change due to the COVID-19 pandemic. Education for sustainable development (ESD) requires an interdisciplinary and student-centred approach to empower students with critical thinking, collaboration and problem-solving skills. Can the learning objectives of ESD be achieved via online learning? Currently, very few studies have evaluated the effectiveness and feasibility of teaching sustainable development online. Since online learning has become the trend in the current education environment, this study aims at investigating the significant factors influencing teachers' perception of teaching sustainable development online during the COVID-19 pandemic. It identified the personal and contextual factors which can be predictors of the teachers' choices on teaching sustainable development online in the post-pandemic era. This study is guided by three research questions:

1. How do teachers describe their experience of teaching sustainable development online?
2. Why do teachers desire to continue teaching sustainable development online in the post-pandemic era?
3. Why do teachers desire to stop teaching sustainable development online in the post-pandemic era?

Design/ methodology/ approach – This study adopts Social Cognitive Career Theory as the theoretical framework for investigating teachers' experience of teaching sustainable development online and presenting their decision-making process on continuing to teach sustainable development online in future. Guided by interpretative phenomenological analysis, the researchers conducted two one-on-one semi-structured interviews with five in-service teachers internationally to examine their online teaching experiences. A general inductive approach was employed in data analysis to generate three themes and six subthemes.

Findings – By an in-depth study of the participants' teaching experiences and decision-making process, the researchers encapsulated and categorized personal and contextual factors — such as personal beliefs, the attainment of teaching goals, and the school support — which influenced their perception and decision on whether to continue to teach sustainable development online.

Originality/value/implications – This is a unique international study which examines the interrelation between personal and contextual variables which influence teachers' perception of teaching sustainable development online by adopting an SCCT lens. Since the United Nations highlighted education for sustainable development (ESD) as a critical step to achieve a win-win situation among people, the planet and prosperity, the findings from this study provide insights for educators, institutes, education policy-makers and school management in reviewing the current implementation of learning sustainable development online and probe into the possibility of implementing online teaching as a regular component in ESD.

Keywords: distance learning; online learning; sustainable development; Social Cognitive Career Theory; Interpretative Phenomenological Approach

1. Introduction

Education for Sustainable Development (ESD) has become increasingly important to empower the current and future generation to become responsible global citizens (Leal Filho et al., 2020; UN, 2016; UNESCO, 2005, 2017). Meanwhile, the COVID-19 pandemic has greatly hampered the progress of attaining sustainable development goals, particularly on its impact on continuity and equality of quality education (Asanov et al., 2021; Iivari et al., 2020; UN, 2020, 2021; Vial, 2019). With the development of various online learning tools, it draws to a discussion of the benefits and concerns of implementing ESD online (Bassey et al., 2009; Dong et al., 2020; Portuguez Castro & Gómez Zermeño, 2020). ESD requires an interdisciplinary and student-centred approach to empower students with critical thinking, collaboration and problem-solving skills (UN, 2016; UNESCO, 2005, 2017). Can the learning objectives of ESD be achieved via online learning? Currently, there is a shortage of studies in evaluating the effectiveness and feasibility of teaching sustainable development online.

1.1 Purpose of the Study

This study aims at investigating the significant factors influencing teachers' decisions of teaching sustainable development online by exploring their teaching experiences during the COVID-19 pandemic. Through examining teachers' experiences of teaching sustainable development online, this study identified the personal and contextual factors which can be predictors of the teachers' choices on teaching sustainable development online in the post-pandemic era (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996).

Based on the purpose of the study, this study is guided by three research questions:

1. How do teachers describe their experience of teaching sustainable development online?
2. Why do teachers desire to continue teaching sustainable development online in the post-pandemic era?
3. Why do teachers desire to stop teaching sustainable development online in the post-pandemic era?

1.2 Significance of this study

This study is a unique international one in examining the interrelation between personal and contextual variables influencing teachers' perception of teaching sustainable development online by adopting a Social Cognitive Career Theory (SCCT) lens. It is also a novel study in the ESD field to examine teachers' mental representation and outline the factors influencing their decision on the choices of teaching medium and contents in relation to their development of self-efficacy beliefs, teaching outcome expectations and teaching goal attainments (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). Since The United Nations highlighted ESD as a critical step to achieve a win-win situation among people, planet and prosperity (UN, 2016; UNESCO, 2005, 2017), the findings from this study provide insights for educators, institutes, education policymakers and school management in reviewing the current implementation of learning sustainable development online and probe into the possibility of implementing online teaching as a regular component in ESD.

2. Literature Review

Currently, studies about online ESD learning are centred on its benefits and concerns (Bassey et al., 2009; Dong et al., 2020; Portuguez Castro & Gómez Zermeño, 2020). Among them, most of the studies (Castro 2020, Brudermann 2019, Li 2018, Rashid 2019, Sivapalan 2017) were focussing on the implementation in higher education. Very few of the studies (Nguyen et al., 2020; Roy et al., 2012) focussed on K-12 education. This section first outlines the contribution of the previous studies, followed by identifying the research gaps to posit the current study.

First, scholars (Bassey et al., 2009; Portuguez Castro & Gómez Zermeño, 2020) generally agreed that information technology is an essential component to attain the goal and quality of ESD. One of the benefits of online ESD learning is that it meets different students' learning needs through user behaviour analysis, content analysis and interactive interfaces, whereby students can embrace the social values and scientific knowledge in problem-solving in accordance with their learning styles (Bassey et al., 2009; Brudermann et al., 2019; Li & Zhou, 2018; Sivapalan et al., 2016).

Another benefit of adopting online ESD learning is the attainment of the learning goals of ESD of taking up the responsibility to create a sustainable future (Leal Filho et al., 2020; UNESCO, 2005, 2017). By equipping students with technological skills and competencies, students have a deeper discussion in an authentic context without pressure (Blizak et al., 2020; Dos Santos, 2019; Hyland, 2007; Manegre & Sabiri, 2020; Portuguez Castro & Gómez Zermeño, 2020; Skehan, 2003; UNESCO, 2005, 2017). The transdisciplinary problem-oriented and student-oriented teaching in online ESD allows students to acquire critical thinking and system thinking, thereby attaining the learning objectives of ESD (Bezeljak et al., 2020; Brundiers et al., 2010; Dlouhá & Burandt, 2015; Du et al., 2013; Kalsoom & Khanam, 2017).

Third, online ESD learning also demonstrates its edge at its flexibility (Bassey 2009, Castro 2020). The timely feedback and interaction on online learning platforms can provide ample opportunities for students to reflect on different values and beliefs critically in various contexts and discourses at a faster rate (Blizak et al., 2020; Coulter et al., 2007; Ellis, 2000; Garrison & Cleveland-Innes, 2005; Hyland, 2007; Skehan, 2003). With the sharing of learning resources on the Internet and the reflective activities sources, students can devise solutions at local and global levels (Brudermann et al., 2019; Li & Zhou, 2018; Portuguez Castro & Gómez Zermeño, 2020; Roy et al., 2012).

However, some scholars (Brudermann et al., 2019; MacIntyre et al., 2020; UN, 2020) are sceptical towards the online course format in ESD. A lack of relevant training hampered teachers' motivation in implementing ESD (Sinakou et al., 2019; Summers et al., 2005; Walshe, 2017). Teachers generally felt the transdisciplinary approach in ESD ambiguous (Berglund & Gericke, 2016; Corney, 2006; Sinakou et al., 2019). As a result, some teachers preferred staying with the traditional pedagogies (Berglund & Gericke, 2016; Corney, 2006; Sinakou et al., 2019).

Second, concern is also raised on the students' access to technological resources in online ESD learning, whereby a lack of the Internet and internet-connected devices can pose a threat to the underprivileged students' learning effectiveness (Rashid, 2019). Such concern can be reflected in those students' lower class attendance and homework submission rate (Asanov et al., 2021; Sachs et al., 2019; UN, 2020). It can make those children more vulnerable by limiting their chances to access to quality education, which defeats the purpose of the ESD (Asanov et al., 2021; Sachs et al., 2019; UN, 2020).

Although previous studies (Bassey et al., 2009; Portuguez Castro & Gómez Zermeño, 2020) have made a contribution of evaluating the benefits and concerns of online ESD learning, very few of the studies (Yilmaz 2021, Bezelijak 2020) examined teachers' experiences of teaching sustainable development online. Successful teaching comprises teachers' beliefs, classroom setting and teaching pedagogies, whereby teachers take a pivotal role to bring the utmost learning outcomes to students (Cantrell et al., 2003; Placer & Dodds, 1988). Although there were some previous studies (Corney, 2006; Eli et al., 2020; Jóhannesson et al., 2011; Summers et al., 2005; Winter, 2007) focusing on teachers' motivation in ESD, those studies perceived teachers are passive respondents towards the unfavourable environment and neglected their capabilities in bringing in changes amidst challenges (Bandura, 1986; Kwee, 2021). Given the fact that online learning can become a 'new common' in the post-pandemic era (Asanov et al., 2021; Blizak et al., 2020; Iivari et al., 2020; Manegre & Sabiri, 2020; UN, 2020), it is necessary to examine teachers' online ESD teaching experience and understand 'how' and 'why' teachers making decisions of teaching sustainable development online.

3. Theoretical Framework

The Social Cognitive Career Theory (SCCT) is chosen as the theoretical framework in this study. Scholars (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996) developed the SCCT based on Bandura's Social Cognitive Theory (1986) to explore the problems related to career choices and decisions specifically. Through examining the reciprocal relationship between self-efficacy, outcome expectation and goal attainment, the SCCT allows the researchers in this study to attain an understanding of how their choices of teaching sustainable development online develop and persist (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996).

First, by adopting the SCCT as the theoretical framework, the researchers can examine how the interplay of personal and contextual variables influences teachers' decisions of teaching sustainable development online, whereby attaining a more accurate mental representation of how teachers turn their interest into actions Adopting the SCCT in this study can allow the researchers to examine the teachers' belief in both ESD and online learning and how these beliefs influence their teaching pedagogies and the attainment of their teaching outcomes holistically (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996).

Second, the SCCT puts great emphasis on the transformative power of an individual to persist and continue their actions amidst challenges (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). By adopting the SCCT in this study, the researchers can examine how teachers' self-efficacy is developed through their postulation of teaching outcome and the attainment of their teaching goals. By unfolding the development of their self-efficacy, it can better understand how teachers' motivation develop so that they can take on challenging tasks such as adopting the transdisciplinary approach or implementing various online learning tools more readily (Brown & Lent, 2019; Lent, Brown, & Hackett, 1994; Lent & Brown, 1996).

Third, researchers (Powazny & Kauffeld, 2020; Sparks & Pole, 2019) accredited the power of the SCCT of offering a more precise cognitive and psychological mechanism with its consideration of personal beliefs, past experiences, social supports and barriers. This study can offer insights for how specific contextual variables such as ICT support or professional training influence their confidence and perception of their capabilities to accomplish the teaching tasks (Bandura, 1997; Giallo & Little, 2003; Lent & Brown, 1996).

4. Methodology

The Interpretative Phenomenological Analysis (IPA) is chosen as the methodology as the researchers explore the teachers' online teaching experiences of sustainable development instead of generating a list of objective statements about their teaching beliefs and outcomes on ESD in an online learning environment (Alase, 2017; Pringle et al., 2011; Smith, 2004, 2015; Smith & Osborn, 2008). IPA values individuals' experiences through an in-depth analysis of their lived stories and the sense-making process of their lifeworld in their own voices without distortion (Pringle et al., 2011; Smith, 2004; Smith & Osborn, 2008). It can unfold the rich data in each participant's sharing so as to understand how a myriad of variables influence teachers' perception of self-efficacy, outcome expectation and goal attainment (Brown & Lent, 2019; Lent et al., 1994; Smith, 2004; Smith & Osborn, 2008).

4.1 Participants

Five in-service teachers are chosen as the participants of this study by adopting the suggestions from the IPA scholars, where a smaller sample size between five to six participants allows an in-depth analysis of the participants' lived experiences by describing and interpreting the meaning of their experiences in details (Alase, 2017; Smith et al., 2005; Smith & Osborn, 2008). To add credibility of the study, a homogenous sample is selected by choosing participants teaching sustainable development online during the COVID-19 pandemic from five different countries through purposive sampling (Alase, 2017; Bernard, 2006; Etikan, 2016; Patton, 2002; Pringle et al., 2011; Smith & Osborn, 2008). This can give a wider understanding of the phenomenon of teaching sustainable development online (Alase, 2017; Creswell, 2007, 2012; Smith & Osborn, 2008). Since the participants' sharing of experiences may contain sensitive information, the researchers used pseudonyms to protect their identities (Creswell, 2007, 2012; Merriam, 2009). The detailed demography of the participants is listed in Table 1.

Table 1. Demography of the participants.

Name	Gender	Age	Subject taught	Years of experience	Campus Location
Nora	F	Late-30s	History	10+	Australia
Josephine	F	Mid-20s	English	3	Canada
Donald	M	Mid-40s	Geography	10+	Hong Kong
William	M	Mid-30s	Science, Mathematics	8	New Zealand
Katherine	F	Early-30s	English as a Second Language	5	Russia

4.2 Data collection and analysis

To collect the participants' lived stories, two online one-on-one semi-structured interviews with the five participants were conducted (Seidman, 2013). Each interview lasted from 51 to 93 minutes. The first interview was to establish rapport with the participants so that they could share their experiences more comfortably, thereby generating rich data for the studies (Alase, 2017; Smith et al., 2005; Smith & Osborn, 2008). The first interview focussed on the teachers' personal beliefs and their previous teaching experiences. The second interview focussed on their experiences of teaching sustainable development online, including the challenges, decisions and actions. Through semi-structured interviews with open-ended questions, the researchers can not only use the SCCT constructs to explore the teachers' personal and contextual variables influencing their decisions of teaching sustainable development online, but also ask follow-up questions in accordance with the participants' interests and concerns (Alase, 2017; Lent et al., 1994; Lent & Brown, 2006; Smith & Osborn, 2008). All the interviews were recorded and transcribed in a separate electronic device. The transcripts were sent to the participants for member-checking and gaining the approval to process with the later data analysis (Creswell, 2007, 2012). To ensure the validity of the study, the researchers also invited the participants to share videos of their recorded lessons and teaching materials (Creswell, 2007, 2012).

A general inductive approach was employed to reduce the chunks of data and identify the first-level themes and subthemes by open-coding technique. Then the researchers employed axial-coding technique to generate the second-level themes to reduce the number of themes and subthemes for standard reporting (Merriam, 2009; Moustakas, 1994; Patton, 2002). As a result, three themes and six subthemes emerged.

5. Findings and Discussion

Based on the research questions, the researcher categorised the findings into three themes and six sub-themes for reporting. Table 2 summarises the themes and subthemes of this study (Merriam, 2009; Yin, 2009).

Table 2. Themes and subthemes.

Themes and Subthemes		
5.1	Personal Beliefs: Reasons for continuing teaching sustainable development online	
	5.1.1	Previous experiences of online teaching
	5.1.2	Responsibility for sustainable development
5.2	Attainment of teaching goals: Reasons for continuing teaching sustainable development online	
	5.2.1	Developing students' critical thinking skills
	5.2.2	Developing students' global perspectives
5.3	Unsupportive School Management: Reasons for stopping teaching sustainable development online	
	5.3.1	Difficulties in collaboration across departments
	5.3.2	Inadequate ICT support

5.1 Personal Beliefs: Reasons for continuing teaching sustainable development online

Teacher's belief in teaching sustainable development online is influenced by their personal belief in online teaching and ESD (Corney, 2006; Eli et al., 2020; Jóhannesson et al., 2011; Summers et al., 2005; Winter, 2007). According to scholars (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996), teachers who have positive personal beliefs are more likely to expect successful teaching outcomes, thereby strengthening their self-efficacy and motivating them in continuing teaching sustainable development online.

5.1.1 Previous experiences of online teaching. Previous studies (MacIntyre et al., 2020; UN, 2020) suggested that teachers' readiness to the new teaching pedagogies on delivering their teaching contents online can influence their motivation of adopting online teaching. This study showed that teachers who have previous successful experiences of online teaching are more willing to teach sustainable development online. Such successful experiences become a powerful predictor of their future achievement (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). One participant said,

> *"Now [During the pandemic] everything is switched online… I'm fine with all arrangement… The mastery of IT skills is not a problem. I started using Google Classroom before the pandemic. I shared the notes with my students more easily… During the assessment period, I gave instant feedback and replied to my students' concerns quickly on any devices. This gave me confidence to continue with online teaching in the pandemic or even after the pandemic." (Josephine, Canada)*

This study affirmed with the previous studies (Basilaia & Kvavadze, 2020; Blizak et al., 2020; Iivari et al., 2020) that teachers' previous successful experiences in online teaching can boost their confidence, thereby postulating a similar successful teaching outcome in teaching online in the future. The findings also affirmed the SCCT hypothesis that past experience acts as an extra source of self-efficacy for an individual to persist in a particular career action (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). Another participant, Donald, echoed such view. He said,

> *"I can continue with that [teaching sustainable development online] after the COVID [pandemic]... Before [the pandemic, I used different online tools to engage my students in class. I used Kahoot! in checking students' previous knowledge and their learning outcomes in the topics like natural hazards and choices of energy sources… I also used Class Dojo to manage students' learning behaviours in class by giving them rewards... These experiences prepared me to a quick switch to online learning during the pandemic." (Donald, Hong Kong)*

A positive learning environment fostered by online learning constitutes successful background experiences and mastery of skills, whereby teachers become more confident with their ability to cope with the change to remote learning and form a set of positive beliefs of obtaining similar success in their future teaching (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). As a result, they are more likely to continue to teach sustainable development online in the future.

5.1.2 Responsibility for sustainable development. Previous studies (Annan-Diab & Molinari, 2017; Berglund & Gericke, 2016; Eli et al., 2020; Summers et al., 2005) suggested that teachers' negative belief of sustainable development influenced their motivation in ESD. Unlike the previous studies, this study showed that teachers can be motivated to teaching sustainable development online due to their positive personal belief stemming from their sense of responsibility for sustainable development. One participant said,

> *"Sustainable development is not just the business of one nation, but the whole world has to take actions… We need cooperation and conversations to realise a more promising future… Everyone has to take part in it… Education is a way to provide opportunities to reflect and discuss these issues. My lessons are not just about skills of solving Math problems. I want them to be responsible global citizen… They have to be aware of issues like climate changes and social justice." (William, New Zealand)*

This study showed that teachers are motivated to continue teaching sustainable development online as they wanted to realise their personal belief, whereby envisioning students to become aware and responsible for the global issues. Such personal belief is not merely based on their perception of the subjects they teach, but also their sustainability attitude, which includes various environmental, economic and social aspects (Biasutti et al., 2018; Biasutti & Frate, 2017). Another participant, Miranda, shared a similar view. She said,

> *"The corona [COVID-19 pandemic] is a difficult time. Many teachers chose to put away discussions to catch up with the teaching progress. I don't want to compromise... I believe that sustainable development is still an important issue after the pandemic…[for example,] epidemic, poverty, hunger. Changes begin in you and me... We should put more effort to get our students engaged in these goals [sustainable development goals]. It's still possible we can create changes." (Nora, Australia)*

Previous studies (Eli et al., 2020; Jóhannesson et al., 2011; Summers et al., 2005) showed that teachers are reluctant to ESD due to various difficulties in the actual implementation. This study showed that teachers' belief in the sense of responsibility as a global citizen can positively influence them to continue teaching sustainable development regardless of the unfavourable environment and subject content. This affirms with the SCCT hypothesis that personal belief is an extra source of self-efficacy for teachers to persist in their actions amidst the challenges (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996). As a result, they have greater resilience to realise their personal belief in their teaching of sustainable development.

5.2 Attainment of teaching goals: Reasons for continuing teaching sustainable development online

Previous studies (Blizak et al., 2020; Garrison & Cleveland-Innes, 2005; Stodel & Thompson, 2006) suggested that teachers expressed worries about the attainment of teaching goals due to the limitation of effective communications due to the physical absence of teachers and peers in an online learning environment. This study showed a positive relationship between the attainment of teaching goals and online teaching in the teachers' experiences of teaching sustainable development online, thereby affirming that information technology is an indispensable component to ensure the quality and goal attainment of education for sustainable development (Bassey et al., 2009; Brudermann et al., 2019; Li & Zhou, 2018; Sivapalan et al., 2016).

5.2.1 Developing students' critical thinking skills. Critical thinking skill is a cornerstone of ESD, whereby ESD adopts a transdisciplinary approach to develop students' critical assessment of prevailing thoughts by providing evidence and sound arguments to their justifications (Bustami et al., 2018; Mutakinati et al., 2018; UNESCO, 2005, 2017). In this study, teachers used different online learning tools to attain their teaching goal of developing students' critical thinking skills. One participant said,

> *"My students were afraid of making mistakes. Before [the pandemic], they were reluctant to volunteer information because they felt they did not pronounce the words correctly. It was hard to develop their critical thinking due to limited discussion in class… With the collaborative whiteboard, my students were more willing to share their thoughts. They liked writing on it. Sometimes, they drew smiley faces while they agreed with other classmates and wrote 'why' if they need further explanation." (Katherine, Russia)*

Unlike the previous studies (Blizak et al., 2020; Garrison & Cleveland-Innes, 2005; Stodel & Thompson, 2006) suggesting the student engagement was hampered in online learning, the findings in this study showed that students can have reflective and reciprocal communication to convey meaningful information with the collaborative functions of the online learning tools, thereby forming a better learning community (Canale & Swain, 1980; Habermas, 1991; Skehan, 2003). Such learning community can engage students in more in-depth discussions of issues about sustainable development by reducing the stress of students in face-to-face interactions, thereby attaining the teaching goals of ESD (Bassey et al., 2009; Garrison & Cleveland-Innes, 2005; Grant & Lee, 2014). Another participant, Nora, said, *"Developing a PEEL [Point- Example – Elaboration – Link] structure is essential in writing… In discussing gender equality, I used Zoom breakout rooms to lead students in small group discussions. Later they presented their arguments through the screen-sharing function. They typed the questions, clarification, reasons and evidence in the chat, for example, domestic violence, work opportunities… Some groupmates helped to respond to that... They liked this instant way of sharing ideas. They did a good job and I'm proud of their achievement." (Nora, Australia)*

In this study, teachers agreed that online learning tools created a favourable learning environment for students to share their thoughts in depth through a more meaningful and fruitful discussion by embracing different perspectives and using higher cognitive skills. These skills are the indicators of the successful implementation of ESD (UNESCO, 2005, 2017). According to the SCCT (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008), teachers who can attain their teaching goals are more willing to continue their teaching of sustainable development online due to job satisfaction, which can be seen from their positive affections towards students' performance. Another participant, William, echoed,

"Students always think that science and humanity are two separate domains. Teaching sustainable development is a way for them to develop an understanding of these social issues critically by examining the impacts to the environment and people... Now with the online forum, I posted some videos and used some guiding questions to ask them [students] to post their thoughts and reply to the threads… There're always new replies... I'm happy with the way they bring in different perspectives and construct knowledge together." (William, New Zealand)

Teachers in this study reflected that students are more autonomous to initiate and continue with the discussion of the sustainable development issues, whereby they constructed cohesive knowledge with multiple perspectives. Such attainment reflected that students have acquired a higher order of critical thinking and fostered a stronger link between knowledge, social needs and values (Bassey et al., 2009; Brudermann et al., 2019; Garrison & Cleveland-Innes, 2005). Affirmed with the SCCT hypothesis (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008), such fulfilment of teaching goals boosted teachers' positive affection, yielding to greater job satisfaction, thereby motivating teachers to continue their ESD online.

5.2.2 Developing students' global perspectives. One of the goals of ESD is to allow students to examine policies, discuss issues and devise solutions on both local and global levels (Brudermann et al., 2019; Portuguez Castro & Gómez Zermeño, 2020; UNESCO, 2005, 2017). This study reflected that teachers using online learning tools can broaden students' global perspectives to pertain to a broader and deeper understanding of the global issues, thereby attaining their teaching goals. One participant said,

"*When discussing renewable energy, I asked my students to join an online interactive game developed by NOVA Energy Lab to design a renewable energy system for a city. They had to analyse the data about different cities and reference to other successful cities worldwide… They liked that game and wanted to be the top scorers… Now they know more about various sources of renewable energy… They know that international cooperation can be beneficial to energy research… I will definitely use this game next year." (William, New Zealand)*

The findings in this study affirmed that online learning can engage students in thinking of solutions to different social issues from a global perspective (Portuguez Castro & Gómez Zermeño, 2020). The experiences brought by the interactive features of online learning activities such as games successfully engage students in considering the issues globally by taking the initiative in researching the relevant information. Such attainment of the teaching goals positively influences teachers' self-efficacy, and they can expect another successful experience while implementing a similar strategy in their future teaching (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008). Another participant also shared a similar view,

"Some sustainable development issues can be remote to the students… This year I tried to bring some students from Australia into the Zoom classroom. Those students [Australian students] read some bush ballad poems to my students… They [Katherine's students] were impressed by their [Australian students'] love for nature… It brings them a reflection of the dominating attitude of exploiting natural resources... There can be communion between man and nature." (Katherine, Russia)

Previous studies (UNESCO, 2005, 2017) suggested that global perspectives are necessary to lay a foundation for effective communication and understanding between different cultures, thereby creating a sustainable future. In this study, online video-conferencing tools provide a platform allowing an authentic real-time exchange of information, whereby provoking their reflection on their own beliefs and forging a closer bond in understanding the values upheld by people around the world (Blizak et al., 2020; Dos Santos, 2019; Hyland, 2007; Manegre & Sabiri, 2020; Skehan, 2003). One of the participants echoed with such view,

"When teaching women's rights, I showed them some YouTube videos of female right activists, like Malala Yousafzai and Emtithal Mahmoud. They can understand better how girls are deprived of the rights of education and how forced displacement can be impactful... It broadens their understanding of gender equality... It [Gender equality] is not just about workplace or family roles, but also basic human rights... I'm glad that they achieved the learning outcomes… I hope next year another cohort [of students] can also achieve that." (Nora, Australia)

The findings of this study showed that social media platforms broadened students' horizons to attain a more holistic understanding of a sustainable development topic by bringing in voices of different people around the globe, thereby attaining its goal of envisioning the future generation to become a global citizen by raising similar concerns to the plights of individuals around the world. Such attainment of teaching goal become the background experience and source of self-efficacy for teachers to postulate a similar success in future (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008). As a result, they are more likely to continue teaching sustainable development online in the future.

5.3 Unsupportive school management: Reason for stopping teaching sustainable development online

Previous studies (Jóhannesson et al., 2011; Kalsoom & Khanam, 2017; Leo & Wickenberg, 2013; Summers et al., 2005; Winter, 2007) indicated that teachers were demotivated in implementing ESD due to a lack of school support. This study affirmed that in an online learning environment, the unsupportive school management is also a key contextual variable hampering teachers' decision of continuing teaching sustainable development online due to the difficulties in collaboration across departments and inadequate ICT support.

5.3.1 Difficulties in collaboration across departments. Previous studies (Eli et al., 2020; Mansilla & Duraising, 2007; Summers et al., 2005) suggested that the blurred boundary between different subjects made the collaboration across different subject panels difficult. In this study, teachers also faced similar difficulty. One said,

> *"I'm stressed… I can only communicate with my colleagues via emails. Even we have some Zoom meetings… They are about administrative issues. We don't really have chances to discuss the lesson plans and structures. A transit to online platform is too quick in the pandemic. Some of us are not too ready to switch online. To ensure the teaching effectiveness, I have to spend extra time to source the appropriate materials. That's exhausting." (Josephine, Canada)*

Previous studies (Hebert & Worthy, 2001; Iivari et al., 2020; MacIntyre et al., 2020) suggested that online learning does not necessarily provide opportunities for teachers to share their workload to alleviate the teachers' negative affection like stress and anxiety. Although ESD advocates a transdisciplinary approach to integrate various topics related to sustainable development into the curriculum to align with students' learning goals (Biasutti et al., 2018; Biasutti & Frate, 2017), this study reflected that mere online discussions among colleagues on the implementation of such approach is difficult. In order to implement sustainable development in online teaching successfully, teachers have to spend extra time to prepare for the teaching materials, thereby leading to a deterioration in their well-being. Another participant said,

> *"I'm not an expert in science or economics... When I have to teach some topics like climate change or responsible consumer behaviours, I want to get some advice… I want to pick the right materials for my students… I don't know who I can find... I tried to find the head teachers to help. They were too busy and just copied the emails to the colleagues in the same department... Then I had to wait for a few days to get the replies. Sometimes time is really tight and eventually I had to do it all myself... Sometimes it's frustrating." (Katherine, Russia)*

This study reflected that the difficulty in collaboration did not only lie in dividing the work between teachers, but also in synthesising the teaching materials due to a delay in online communication. According to the SCCT (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008), this study showed that teaching sustainable development online can be detrimental to teachers' well-being if they do not receive adequate support in collaboration, thereby diminishing their self-efficacy and perceiving that such teaching is less likely to be successful in future. One of the participants said,

> *"Sometimes I work till midnight to prepare for the right materials… I'm working really slow… I have to read the literature about different camps of thoughts to facilitate the discussions of sustainable development… Health is important. I can't keep on sacrificing my health to work like this [spending extra time preparing the course materials] for a long time… Of course, collaboration can help. But how the school leader makes it happen is another issue." (Donald, Hong Kong)*

Such findings affirmed with that previous studies (Eli et al., 2020; Jóhannesson et al., 2011; Summers et al., 2005) that teachers found it challenging to spare extra time to prepare the course materials without receiving adequate support, thereby negatively influencing their work efficiency and casting doubt on their ability (Acton & Glasgow, 2015; Hastings & Bham, 2003). According to the SCCT (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008), such denial of their ability can lead to a decrease in their self-efficacy postulating a successful career outcome. As a result, teachers are less likely to continue teaching sustainable development online in future.

5.3.2 Inadequate ICT support. Previous studies (MacIntyre et al., 2020; UN, 2020) suggested that one concern of online learning is the technological competencies of teachers. Although participants in this study showed a relevant good mastery of online teaching tools, they also expressed concerns about the inadequate ICT support from schools on supporting students on a smooth transition to online learning. Such concern can be influential to teachers' decision on continuing to teach sustainable development online. One said,

> *"Sometimes I can't see some of my students attending my class. It's not because they are lazy. It's because their brothers or sisters have to use the computer. They also have online classes too. It's heartbreaking… My school doesn't have any plans to loan the devices to those students. I feel powerless to see them missing the opportunities to learn… One of the sustainable development goals is quality education. Now they don't even have the fair access [to education]. It's ironic." (Donald, Hong Kong)*

Previous studies (Asanov et al., 2021; Sachs et al., 2019; UN, 2020) reflected that students who are from lower socio-economic background may have difficulties accessing stable network connections and internet-connected devices, thereby negatively influencing their learning outcomes. This study affirmed that the schools' lack of sensitivity to these students' plight hampered teachers' decision in continuing teaching sustainable development online as they felt social equity is not attained. One of the aims of ESD is to empower students to take up responsibilities to achieve social justice (Leal Filho et al., 2020; UNESCO, 2005, 2017). Teachers felt powerless that they could not achieve social equity in reality while claiming social equity is possible in their lessons. Another participant shared a similar view,

> *"Now [In the pandemic] all lessons are conducted online. Some students' home internet connection is really poor. Some of them live in really remote area. Their videos were frozen and the audio was glitchy. It's ashamed that we just assumed students from all areas got stable internet connection. The schools should think of solutions to ensure every child has equal opportunity to learn. They can initiate cooperation with Telstra or Optus [Internet service providers] for providing cheaper internet plans for school children. Unless this problem is solved, it's unlikely to do all [the teaching] online. I don't want to create a greater gap [inequality]" (Nora, Australia)*

This study reflected that schools were insensitive to the learning needs to the students while switching to online learning, particularly on their access of Internet and devices. Such insensitivity leads to an inadequate support to the students who are from the lower socio-economic background, thereby hampering students to have equal opportunities to access to quality education. Teachers in this study showed strong negative affections towards such inequality, owing to the fact that ESD itself should have been paving a way pertaining to a more equitable future. According to the SCCT (Brown & Lent, 2019; Lent et al., 1994; Lent & Brown, 1996, 2008), such negative emotions, alongside a contradiction between the belief and reality, makes teachers postulate a negative outcome of continuing teaching sustainable development online, which is creating greater social inequality. Such negative outcome expectation hampered them to continue online learning in future.

6. Conclusion

This study is a novel international one contributing to the field of ESD focussing on the online teaching experiences of teachers. Nevertheless, this study shows several limitations. First, the current study shows a limitation of the number of participants. Although the current study encapsulated the factors influencing teachers' decisions on teaching sustainable development online, the few participants involved in the study may affect its generalisability (Almeida 2017). Further research can be expanded to include a larger number of participants (Dos Santos, 2020b, 2020a; Kwee, 2021). Second, this study also showed a limitation on a lack of quantitative data as this study is a qualitative one aiming at unfolding teachers' mental representation of their teaching experience. Further research can be done by using mixed methods like surveys to collect students' and teachers' opinions on teaching sustainable development online, whereby the researchers shed lights on the effectiveness of implementing ESD online from various perspectives (Biasutti & Frate, 2017; Kwee, 2021). Despite the limitations, this study outlined the factors influencing teachers' decision on continuing teaching sustainable development by examining their decision-making process with a SCCT lens. Such findings can be useful in providing insights for the educators, policy-makers and educational institutes to provide better supports like ICT supports and professional development programmes to boost teachers' efficacy and equip them with the relevant skills in implementing ESD online more successfully in future.

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Study on How Change in Carbon Footprint of Online Education in China under COVID-19 Epidemic Conditions Impacts Sustainable Development

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Abstract
Purpose – As COVID-19 spreads across the world, online education has become a norm. In such a context, this study aims to explore the impact of carbon footprint change in online education on sustainable development.
Methodology – This study tries to introduce the concept of carbon footprint, an indicator for quantifying natural resource consumption, to the field of education. Through horizontal comparison and individual evaluation, this study constructs an online education carbon footprint indicator calculation system. The system quantitatively calculates the scale of carbon footprint in three scenarios: the complete online learning stage at the height of the epidemic; the stage in which offline learning, as the main education mode, is supplemented with online learning; and the combination of online and offline education modes in future.
Findings – The following outlines the features of carbon footprint in China according to the research findings. First, the carbon footprint of transport of primary and secondary school students decreased significantly during the epidemic. Second, the carbon footprint from meals of college and university students since the epidemic outbreak has been significantly higher than before. Third, when online education accounts for 60% and offline learning accounts for 40%, the carbon footprint will reduce. Fourth, the per capita carbon footprint of transport from college and university students in China is lower than that of foreign students, but more carbon footprint is generated from daily life.
Implications – This study is expected to provide useful reference to research on the impact of China's online education on green campus construction and low-carbon sustainable development. It shall therefore be strong support for China's implementation of the 'carbon peak and carbon neutrality' strategy.

Keywords: online education; scenario simulation; carbon footprint; sustainable development

1.0 Research Background

1. China’s online education has been developing fast and strong with diversified content due to the outbreak of the epidemic

Online education, namely E-Learning, is a means of content communication and knowledge learning using the internet information technology. According to the data released by UNESCO, up till 30 March 2020, more than 1.5 billion learners around the world have been affected by the COVID-19 to varying degrees. A total of 181 countries have adopted nationwide school closures, which are estimated to affect more than 87% of the school students worldwide. In order to mitigate the impact of the epidemic on normal education and teaching, UNESCO introduces or expands the distance education model to ensure the sustainability of learning for students around the world. Distance and online education has become the mainstream educational form in this special time (Shi and Fan, 2020). Since 2013, China’s online education market and its user scale have been expanding continuously, with a solid technical guarantee provided by 5G, big data, the internet of things, cloud computing, virtual reality, artificial intelligence and other new generation of information and communication technologies. Online higher education courses have also rapidly expanded from relatively single and individual majors at the beginning to cover 12 undergraduate disciplines and 18 specialty categories of junior college and higher vocational colleges (Zhang et al., 2021). According to the 2019 China Online Education Market Data Report, the value of China's online education market has reached 346.8 billion yuan, which is an increase of 21.47% compared to last year. In China, online education is a new learning model based on the internet, including general platforms and courses such as Tencent classroom, coaching platforms such as Apes Tutoring, language platforms such as Akaso Foreign Education Network, IT platforms such as Programming Cats, vocational education platforms such as Gordon Education, mathematics platforms such as Spark Thinking, music platforms such as VIP training partner. In terms of user scale, the number of online education users in China reached 269 million in 2019, which was an increase of 33.83% compared to 2018 (Hu, 2020). The Fifth Plenary Session of the 19th CPC Central Committee proposed to give full play to the advantages of online education, in order to improve lifelong learning system construction and build a learning society. In the future, online education will undoubtedly integrate into all kinds of traditional education forms at various levels rapidly with its unique advantages.

1.2 General Secretary Xi Jinping put forward the "two-step" strategic vision of carbon peak and carbon neutrality at the 75th session of the United Nations General Assembly

On September 22, 2020, President Xi Jinping delivered a speech at the General Debate of the United Nations General Assembly, promising that "China will scale up its *Intended Nationally Determined Contributions* by adopting more vigorous policies and measures. We aim to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060." At this difficult time of global crisis, China proofed to achieve carbon neutrality as our vision by midcentury as a long-term development strategy of low greenhouse gas emissions. This has showed our determination and courage to take the sustainable development path unswervingly. It is a clear long-term policy signal of green and zero-carbon economic transformation. Green and low-carbon development is not against economic growth, on the contrary, it will promote high-quality economic growth and force the unsustainable development mode to transform (Chai et al., 2020).

1.3 The development of online education will provide strong support for this strategic goal

"Carbon footprint" is also called carbon fingerprint and carbon emissions. An individual's carbon footprint is a process to estimate the carbon emissions caused by food, clothing, housing and transportation in a person's daily life (Luo et al., 2010). The main carbon footprint in China is the carbon dioxide directly emitted by the burning of fossil fuels in the process of transportation (Wang and Shi, 2009).

Higher institutions is considered to be an important part of low-carbon society and low-carbon city and one of the main energy consuming units, therefore the construction of low-carbon campuses has profound social significance (Liu et al., 2019). From the perspective of carbon footprint: online meetings, seminars, training and other communication activities, online learning, homework, examination and other teaching segments have shown that the high carbon behavior of transportation are likely to be replaced. Therefore, online education will help promote green, low-carbon and sustainable development of campuses, and provide strong support for the implementation of China's "carbon peak and carbon neutrality" strategy in the field of education.

2.0 Research Objectives

One way to measure the impact of human behavior on the natural environment is to measure its carbon footprint. So far, the academia hasn’t reached consensus about the connotation of carbon footprint. In this paper, carbon footprint is defined as "the energy consumption transferred into the amount of carbon dioxide (CO_2) per person per year, which is used to measure the impact of human activities on climate change." This paper aims to compare impacts of the carbon footprint changes of China’s online and offline education on its sustainable development during different stages of the epidemic.

2.1 Impact of online learning intensity on carbon footprint under different epidemic situations in China

According to the trend of the epidemic and the policy adjustment of the Ministry of Education, online education during the epidemic can be divided into the following three stages:

Complete online learning stage at the height of the epidemic period: On January 29, 2020, the Ministry of Education clearly required "class suspended, but learning continues" all over the country. This “paused” offline education, but "fast forwarded" the online education. On February 17 that year, the Ministry of Education officially launched the National Online Cloud Platform for Primary and Secondary Schools and the China Education Television Classroom in the Air, offering large-scale online education to 180 million primary and secondary school students across the country.

Most higher education institutions across the country started online teaching on the original first day of school, and by May 8 that year, 1,454 colleges and universities across the country had implemented online teaching.

Online and offline connecting stage at the normalization of the epidemic period: Since April 29, 2020, nationwide epidemic prevention and control has entered a normal stage. From May to June, some students returned to campuses in batches. Students took online classes and studied by themselves at school, therefore this period can be considered as a connecting stage of online and offline education.

Offline learning as the main mode with online learning as the supplement mode stage: From the end of August to September 2020, students from primary and secondary schools (including secondary vocational schools) and universities (including higher vocational schools) returned to schools in batches at different times. Off-campus training institutions resumed offline courses and activities, and started a mode of offline learning as the main mode with online learning as the supplement mode.

2.2 Exploring the relationship between the level of online learning behavior and the sustainable development of China

The evaluation of education carbon footprint has been developing fast, and so far many countries have published their research results (Filimonau et al., 2021). Studies from other countries have shown that the carbon footprint of higher education is mainly related to traffic emissions due to learning and research on and off campus (Baboulet and Lenzen, 2010; Bailey and Lapoint, 2016; Caird et al, 2015; Robinson et al., 2015; Townsend and Barrett, 2015; Versteijlen et al., 2017). However, the research on Tongji University from Tan (2014) shows that Chinese students mainly live in dormitory (4-6 people in one dorm) on campus, and their main transportation means are walking and cycling, plus they don't travel much, so their carbon footprint is much smaller. Transportation is not the main factor affecting the carbon emission of higher education in China. Canteen meals and public showers contribute the most to individual carbon footprint of students (Li et al., 2015) (Table 1), which is different from the research results of developed countries. Therefore, it remains to be seen whether online learning significantly reduces China's education carbon footprint. Exploring the relationship between the proportions of online and offline learning and carbon footprint, and promoting policy formulation and management plan tailored to local conditions will contribute to the construction of energy-saving campuses and achieve the goal of sustainable development.

Table 1. Comparative studies. University CO_2 expenditure

Title and University	Reference	Transport	Academic Activities	Daily Life
"Design of higher education teaching models and carbon impacts", (University of Mahidol)	Fan et al.,2021	40%	31%	16%
"Carbon footprint analysis of student behavior for a sustainable university campus in China", (University of Tongji)	Güereca et al., 2013	20%	15%	65%
"Estimation of the carbon footprint of student halls of residence in the University of Strathclyde" (University of Strathclyde)	Xiao, 2015	58%	42%	
"Investigating the Carbon Footprint of a University —The case of NTNU"	Ranganathan and Bhatia, 2004	16%	19%	65%
Journal of Energy in Southern Africa., vol. 22, no. 2. University of Cape Town (University of Cape Town)	Wen, 2012	18%	1%	81%
"Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study", (University of Cape Town)	Eggleston et al, 2006	28%	34%	38%
"Carbon Footprint of Environmental Science Students in Suan Sunandha Rajabhat University, Thailand", (University of Rajabhat)	Tan et al., 2012	15%	41%	44%

3.0 Research Methods

3.1.1 The construction of horizontal comparison system of online education carbon footprint

In order to better understand the differences in the educational carbon footprints of students from different universities in different regions, Perales Jarillo (2019) have compared the carbon footprints of students from several universities in China, the United Kingdom, Thailand, South Africa and Norway. In addition, we supplemented the data from two Chinese universities and two American universities.

3.1.2 The construction of online education personal carbon footprint evaluation procedure

Since previous studies focused on the estimation of greenhouse gas emissions of schools as a whole, there were few statistics on the carbon footprint effect of students' activities. Our study focused on the carbon footprint of individual student caused by online learning and offline learning. We define the research object as ordinary individual student, and plan to focus on the impact of online learning behavior of college and university students, and primary and secondary students on their individual carbon footprint.

The fact that schools were closed and students had to study at home during the epidemic was an extreme condition for this study: 100 percent online education with schools completely closed. However, as the epidemic has become a normal situation, people have resumed their study which provides us with another mode: completely offline education, and no online education in school. We construct a fourth model according to the real situation of China's epidemic development: In the future, the combination of online and offline learning prediction mode. It is a combination of traditional education and online education. Students can preview, search for materials, study and practice online, and then discuss, report and answer questions offline. In terms of daily effective learning time, we assume that the traditional offline learning time will account for 40% and the online learning time will account for 60%. This time proportion is in consistent with the schedule of the Problem-based Learning (PBL) teaching method of Peking University (Fan et al., 2021).

Since the Online and offline connecting period is short after the epidemic has become a normal situation, and only a small number of graduate students have applied to return to school in advance, this online learning way is a special state in a special period and therefore cannot be replicated, so our research does not focus on this period.

Table 2 outlines the carbon emission evaluation procedure.

Table 2. Carbon footprint assessment procedure

Stage	Purpose	Method	Output
1	To obtain inventory data for carbon footprint assessment of on-site operations	Direct mearsurements (From database) / surveys / analysis	Inventory data of on-site carbon impacts
2	To establish the pattern of studying from home	Interviews /surveys	Inventory data of on-home carbon impacts
3	To assess the carbon footprint of blended teaching pattern	Simulation /prediction	Combined carbon footprint estimates

Figure 1 shows the scope and variables of the system for carbon footprint evaluation during the epidemic for offline learning. The setting of the system variables refers to the study of Filimonau (2021) and the Guidelines for Verification of Enterprise Greenhouse Gas Emission Report (March 29, 2021) issued by the Ministry of Ecology and Environment of People's Republic of China.

During the offline study period, the traffic situation of students is obtained by the survey. During the epidemic, the campuses were completely closed and students were not allowed to go outside, therefore the traffic energy consumption was zero which led to no carbon footprint. Variables related to study at home were considered in the carbon footprint evaluation system, such as daily meals consumption, kitchen appliances, etc. This is the energy consumption mode during the complete online learning situation (Figure 1). The carbon footprint data of study at home was collected by survey and interviews. Domestic heating factors, waste water discharge and household waste were not considered due to the difficulty of data collection. Living factors such as online shopping were not included in the analysis because they were not directly related to study at home. Most university dormitories in China do not allow cooking, so during offline study, the carbon footprint of kitchen appliances is zero, and the main appliances used for offline study are computers and desk lamps.

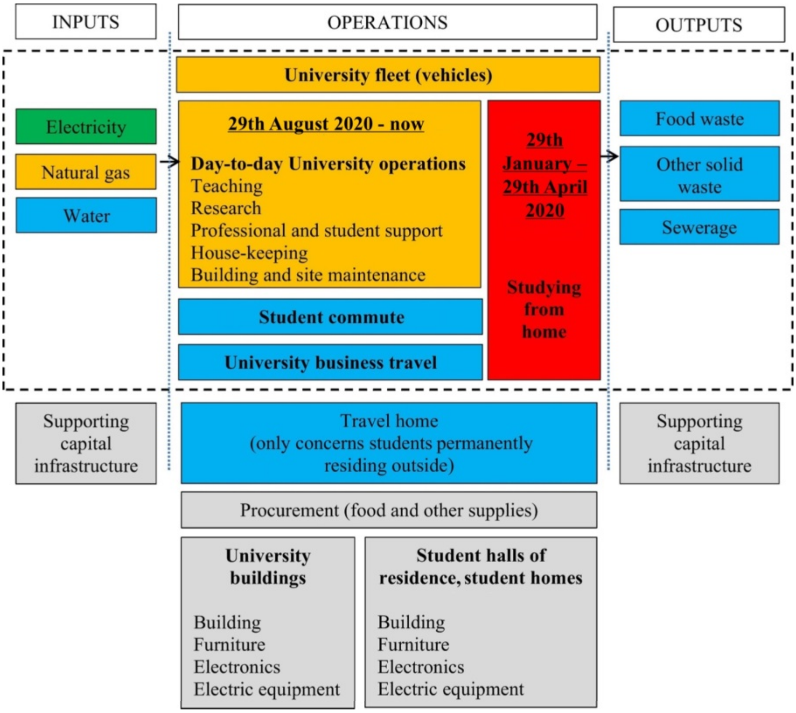

Figure 1. System boundary and variable for carbon footprint assessment

After investigation and interviews, this study summarized the "average" schedule patterns of Chinese primary and secondary school students and college and university students before the epidemic closure period and during offline normal teaching period (Figure 2). According to the interview results, the schedule of primary and secondary schools in China are almost the same. From Monday to Friday, primary school students start classes at 8 am and finish at 4 PM on average, while junior middle school students finish classes at 5 PM. High school students face the pressure of college entrance examination. Thus, schools usually arrange self-study in the evening, and the average self-study classes finish at 10 PM.

<table>
<tr><th>Education stage</th><th>Primary school</th><th>Middle school</th><th>High school</th><th>University</th><th colspan="4">Pattern of studying at school</th></tr>
<tr><th>Time</th><th colspan="5">Activity consuming energy</th><th colspan="3">Equipment / Device / Appliance consuming energy</th></tr>
<tr><td colspan="9">START</td></tr>
<tr><td>7:00</td><td rowspan="14">Students: Attendance of classes and do homework</td><td rowspan="15">Students: Attendance of classes and do homework</td><td rowspan="16">Students: Attendance of classes / self-study / revision and do homework</td><td rowspan="16">Students: Attendance of lectures / seminars / tutorials, self-study and revision</td><td>Breakfast</td><td rowspan="16">Inroom lighting: 5 Hours</td><td rowspan="16">Laptop / Desk PC / Smartphone / Pad: 1 Hour</td><td>Go to school</td></tr>
<tr><td>8:00</td><td rowspan="4"></td><td rowspan="9"></td></tr>
<tr><td>9:00</td></tr>
<tr><td>10:00</td></tr>
<tr><td>11:00</td></tr>
<tr><td>12:00</td><td rowspan="2">Lunch</td></tr>
<tr><td>13:00</td></tr>
<tr><td>14:00</td><td rowspan="3"></td></tr>
<tr><td>15:00</td></tr>
<tr><td>16:00</td></tr>
<tr><td>17:00</td><td rowspan="2">Dinner</td><td rowspan="2">Leave school</td></tr>
<tr><td>18:00</td></tr>
<tr><td>19:00</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>20:00</td></tr>
<tr><td>21:00</td><td rowspan="2">FINISH</td></tr>
<tr><td>22:00</td><td>FINISH</td></tr>
<tr><td colspan="9">FINISH</td></tr>
<tr><th>Education stage</th><th>Primary school</th><th>Middle school</th><th>High school</th><th>University</th><th colspan="4">Pattern of studying from home during the COVID-19 lockdown</th></tr>
<tr><th>Time</th><th colspan="5">Activity consuming energy</th><th colspan="3">Equipment / Device / Appliance consuming energy</th></tr>
<tr><td colspan="9">START</td></tr>
<tr><td>7:00</td><td rowspan="14">Students: Attendance of classes and do homework</td><td rowspan="15">Students: Attendance of classes and do homework</td><td rowspan="16">Students: Attendance of classes / self-study / revision and do homework</td><td rowspan="16">Students: Attendance of lectures / seminars / tutorials, self-study and revision</td><td>Breakfast</td><td rowspan="16">Inroom lighting: 5 Hours</td><td rowspan="16">Laptop / Desk PC / Smartphone / Pad: 6-9 Hours</td><td>Electronic cooker / Frying pan</td></tr>
<tr><td>8:00</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>9:00</td></tr>
<tr><td>10:00</td></tr>
<tr><td>11:00</td></tr>
<tr><td>12:00</td><td rowspan="2">Lunch</td><td rowspan="2">Electronic cooker / Frying pan
Pressure cooker / Steamer / Clay pot</td></tr>
<tr><td>13:00</td></tr>
<tr><td>14:00</td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>15:00</td></tr>
<tr><td>16:00</td></tr>
<tr><td>17:00</td><td rowspan="2">Dinner</td><td rowspan="2">Electronic cooker / Frying pan
Pressure cooker / Steamer / Clay pot</td></tr>
<tr><td>18:00</td></tr>
<tr><td>19:00</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>20:00</td></tr>
<tr><td>21:00</td><td rowspan="2">FINISH</td></tr>
<tr><td>22:00</td><td>FINISH</td></tr>
<tr><td colspan="9">FINISH</td></tr>
</table>

Figure 2. An averaged pattern of working/studying from home during the COVID-19 lockdown and the regular epidemic prevention and control

The schedules for college and university students depend on the number of their selected courses. Generally speaking, college and university courses are scheduled from 8 am to 10 PM. In addition to the arranged courses, students normally choose to do their assignments and study by themselves in their spare time, and many college and university students even stay up all night to study (Wen, 2012). We hold the opinion that the average time for college students to finish their study is 10 PM according to the library closure time.

Our study assumes that the student's schedule during the epidemic period remains unchanged under the condition of family supervision and fixed school curriculum arrangement. We assume the learning time spent on learning electronic devices (smartphones, tablets and desktops) was consistent with the effective learning time. As the epidemic has become a normal situation, online learning time was greatly reduced, and the average time spent on electronic devices was one hour per day.

3.2 Carbon footprint measurement of online learning under different scenario simulations

Table 3. Student top 10 energy activities and CO_2e emission calculation summary

Category		Subcategory	Activity	Calculation
Daily life		Dining	Dining in dining hall	Total dining hall GHG/day, divided by average daily number of students served, times self-reported number of meals per year
			Dining in restaurant	Total average restaurant GHG/day, divided by average daily number of students served, times self-reported number of meals per year
		Showering	Showering in dorm	Average GHG/shower (all-electric in-dorm water heater) based on reported operation time per shower, times self-reported showers per year
			Showering in communal facility	Average GHG/RMB, times student self-reported shower cost in RMB
		Electricity , including lamps for study and studying if dorm is primary study location	Computer use (entertainment)	GHG/hour for a generic computer, times self-reported hours used for entertainment per year
			Hot drinking water	GHG/hour for a generic hot drinking water heater, times self-reported hours used per year
			Dorm GHG/year from utility bill, subtract computer use (both entertainment and study), hot drinking water, shower water heater in dorm	
Academics	Computer use (study)	Computer use in classroom, library, or personal office (study)	GHG/hour for a generic computer, times self-reported hours used for study per year	
	Printing	Printing	GHG/page for a generic printer, times self-reported pages printed per year	
	Scanning	Scanning	GHG/scan for a generic scanner times self-reported scans per year	
	Studying (*mutually exclusive*)	Classroom	Average classroom building GHG/hour as function of time divided by classroom design occupancy divided by reported fractional occupancy, integrated from reported study time start to end	
		Library	Average library building GHG/hour as function of time divided by library design occupancy divided by reported fractional occupancy, integrated from reported study time start to end	
Transportation	Daily commuting	Commuting by shuttle bus, train, or car (modes are *mutually exclusive*)	Average GHG/km for mode, times self-reported distance traveled per year	
	Hometown traveling	Travel by driving, train, bus or airplane (modes are *mutually exclusive*)	Average GHG/km for mode, times self-reported distance traveled per year	
	Vacation traveling	Travel by car	Average GHG/km for driving, times self-reported distance traveled per year	
		Travel by airplane	Average GHG/km for flying, times self-reported distance traveled per year	

A student's personal carbon footprint is the sum of the direct carbon emissions of all activities in a year, including daily living, study and transport. The greenhouse gas (GHG) emissions for each of the different activities in these categories can be estimated in a quantitative way.

As mentioned earlier, the study estimated individual carbon footprint: carbon dioxide equivalent emissions (GHG emissions) directly related to student's activities, including behaviors that students can change, such as where to eat, study and bathe, how to use personal electronics, and how to transport and travel. It does not include upstream and downstream carbon emissions, which are hard to quantify. We presume that the unit GHG emission factor for each activity identified in Table 3 is F_i. The units of F_i depend on the type of action: it can be a meal, a shower, money (RMB), hours, KWH, pages or kilometers. U_i represents the number of units per year associated with i activity

Except for learning, the carbon footprint of the other activities (i = 9 and 11, described below) was the product of the emission coefficient and the intensity of the activity or the number of units of activity used by the students.

$$GHG_i = F_i \cdot U_i, \qquad i = 1 \cdots 11, \qquad i \notin \{9,10\} \qquad (1)$$

Table 4. GHG emission factors for consumption of resources and specific end-use components

i	Resource or activity	*Fi (kgCO₂e per unit)*	Unit	Reference
–	Coal	0.34	kWh	Wen,2012
–	Electricity (subscript: *e*)	0.79	kWh	
–	Gasoline	3.19	kg	
–	Natural gas (subscript: *ng*)	4.05	m3	
–	Potable water	0.19	m3	
–	Food production	0.47	kg	
1	Dining in dining hall	0.73	meal	Li et al., 2015
2	Dining at home	1.21	meal	
3	Showering in dorm	Equation 2	shower	
4	Showering in at home	0.32	RMB	
5	Home electric miscellaneous	0.85	kWh	
6	Dorm electric miscellaneous	0.79	kWh	
7	Computer and smartphone use (study)	0.079	hour	
8	Printing and scanning	0.0043	page	
9	Studying: classroom	Equation 5	hour	Calculation
10	Studying: library	Equation 6	hour	
11a	Traveling by shuttle bus	0.029	km	The Peoples Republic of China Climate Change the Second National Report
11b	Traveling by train	0.068	km	
11c	Traveling by personal car	0.27	km	
11d	Traveling by bicycle	0	km	

The unit emission coefficient is derived from the data released by the National Development and Reform Commission in accordance with the Kyoto Protocol and "Guidelines for National Greenhouse Gas Inventories" (Eggleston et al., 2006). The emission coefficient of coal, oil, natural gas, water and electricity and other resources in Beijing and the unit emission coefficient of a specific activity in this study are shown in Table 4.

The impact factors of daily showering (SHD) were as follows:

$$F_{SHD} = P_{SHD}(N) \cdot F_e \qquad (2)$$

P_{SHD} represents the average power of water heater for shower in the dormitory or at home. N is the number of showers per day. F_e is the power factor in units per kilowatt-hour in Table 4. The average daily shower power is P_{SHD}, and as the formula is as follows:

$$P_{SHD}(N) = \frac{P_w N + P_s(24 - N)}{24} \qquad (3)$$

P_w is the power selected for the heating mode, and P_s is the standby power. The total CO_2e emission from showers per student is the number of showers per day multiplied by the shower factor P_{SHD}.

In most cases, estimates require an annual number, such as how many hours per day are converted into how many hours per year. Dormitory or household (EM) electricity consumption is a combination of non-shower electricity consumption. In order to avoid double calculation of shower energy consumption, the calculation method is as follows (unit: kWh):

$$U_{EM} = U_5 + U_6 + U_7 = \left(\frac{B_{EM}}{C_e}\right) \cdot N_{month} - E_{accounted} \tag{4}$$

B_{EM} is the electricity cost of the interviewees' dormitories or transport, C_e is the electricity price, and N_{month} is the average monthly electricity consumption of students living at home or in school dormitories. $E_{accounted}$ is the amount of power consumed by showers and e-learning equipment that has been calculated.

The only thing that currently does not follow the equation (1) is the carbon emissions associated with learning (i = 9 and 10). By "learning", we mean greenhouse gas emissions from classroom buildings and libraries wheire students study.

A small fraction of a building's CO_2 emission rate is the building's total GHG emission rate divided by the number of students. The whole-construction time-dependent average GHG emission rate R ($kgCO_2/h$) was calculated in advance. For example, R_{CL} is the average GHG emission trajectory of classroom buildings. It can be calculated in two ways: the product of the total classroom power consumption (kW) and electric power emission factor F_e ($kgCO_2/kWh$) in time t, and the product of the total utilization rate of natural gas in the classroom (m^3/h) and natural gas emission factor F_{ng} ($kgCO_2/m^3$) in time t.

Students numbers in classrooms are represented by N_{CL} and student numbers in libraries are represented by N_{LB}. These numbers are determined by seat occupancy rates or by estimation.

The total carbon emission of learning changes over time and is multiplied by the number of days that students study each year. The equation is as follows:

For primary and secondary school students and college students studying in the classroom:

$$GHG_9 = \begin{cases} N_{month} \cdot 30 \cdot \int_{t_s}^{t_e} \frac{R_{CL}(t)}{N_{CL} r} dt, & \text{if classroom is primary study location} \\ 0, & \text{else} \end{cases}$$

For college students studying in libraries:

$$GHG_{10} = \begin{cases} N_{month} \cdot 30 \cdot \int_{t_s}^{t_e} \frac{R_{LB}(t)}{N_{LB} r} dt, & \text{if library is primary study location} \\ 0, & \text{else} \end{cases}$$

N_{month} represents the total month numbers of each academic year, which is 9 months a year. 30 is the number of days in a month. t_s and t_e represents the day students begin their study and the day they finish their study. r is the interviewee's evaluation of the full occupancy rate of public space during the study period.

Table 5. Calculation formula of carbon footprint under three scenarios

	The peak of the epidemic is in the stage of complete online learning	Offline learning as the main mode and online learning as the supplement mode	Offline learning as the main mode and online learning as the auxiliary mode
Primary and middle school students	$Sum(GHG) = F_i \bullet U_i$, $i = 2,4,5,7,8$	$Sum(GHG) = F_i \bullet U_i + GHG_9$, $i = 1,4,5,7,8,11$	$Sum(GHG) = F_i \bullet U_i + GHG_9$, $i = 1,2,4,5,6,7,8,11$
University students	$Sum(GHG) = F_i \bullet U_i$, $i = 2,4,5,7,8$	$Sum(GHG) = F_i \bullet U_i + GHG_9$, $i = 1,4,5,7,8,11$	$Sum(GHG) = F_i \bullet U_i + GHG_9$, $i = 1,2,4,5,6,7,8,11$

Based on this, this research presents the equations as follows for three scenarios (Table 5), which are "complete online learning stage during the height of the epidemic", "offline learning as the main mode with online learning as the supplement mode stage" and "offline learning as the main mode and online learning as the auxiliary mode". After calculation, the results are shown in Table 6.

Table 6. Comparative analysis of carbon footprint

University student

Activity	tCO_2e/person	% of total
Carbon footprint under normal circumstances		
Dining	1.24	33.80%
Showering	0.65	17.66%
Electricity	0.5	13.65%
Hometown traverling	0.36	9.80%
Computer use	0.24	6.60%
Smartphone use	0.24	6.60%
Printing and scanning	0.17	4.65%
Vacation traveling	0.14	3.80%
Study in library	0.06	1.65%
Study in classroom	0.04	1.05%
Sum	3.64	100%
Carbon footprint of Blended teaching pattern		
Dining	1.28	32.32%
Showering	0.68	17.17%
Electricity	0.68	17.17%
Hometown traverling	0.28	7.07%
Computer use	0.35	8.84%
Smartphone use	0.33	8.33%
Printing and scanning	0.19	4.80%
Vacation traveling	0.07	1.77%
Study in library	0.06	1.52%
Study in classroom	0.04	1.01%
Sum	3.96	100%
Carbon footprint under the COVID-19 lockdown		
Dining	1.38	29.36%
Showering	0.72	15.32%
Electricity	0.85	18.09%
Hometown traverling	0	0.00%
Computer use	0.94	20.00%
Smartphone use	0.53	11.28%
Printing and scanning	0.28	5.96%
Vacation traveling	0	0.00%
Study in library	0	0.00%
Study in classroom	0	0.00%
Sum	4.7	100%

Primary and middle school student

Activity	tCO_2e/person	% of total
Carbon footprint under normal circumstances		
Dining	0.89	25.07%
Showering	0.56	15.77%
Electricity	0.32	9.01%
Home-school commuting	1.35	38.03%
Computer use	0.04	1.13%
Smartphone use	0.11	3.10%
Printing and scanning	0.04	1.13%
Vacation traveling	0.15	4.23%
Study in library	0.05	1.41%
Study in classroom	0.04	1.13%
Sum	3.55	100%
Carbon footprint of Blended teaching pattern		
Dining	0.91	26.53%
Showering	0.57	16.62%
Electricity	0.33	9.62%
Home-school commuting	1.22	0.00%
Computer use	0.05	1.46%
Smartphone use	0.13	3.79%
Printing and scanning	0.04	1.17%
Vacation traveling	0.09	0.00%
Study in library	0.05	0.00%
Study in classroom	0.04	0.00%
Sum	3.43	100%
Carbon footprint under the COVID-19 lockdown		
Dining	0.97	37.16%
Showering	0.62	23.75%
Electricity	0.68	26.05%
Home-school commuting	0	0.00%
Computer use	0.15	5.75%
Smartphone use	0.13	4.98%
Printing and scanning	0.06	2.30%
Vacation traveling	0	0.00%
Study in library	0	0.00%
Study in classroom	0	0.00%
Sum	2.61	100%

4.0 Research Findings

4.1 The carbon footprint of primary and secondary school students is slightly smaller than the previous research results, and the decrease of students' transportation carbon footprint is the most obvious during the height of the epidemic

The average annual carbon footprint of each student in China is 3.55-3.64TCO_2e, which is smaller than the previous survey result of 4.1TCO_2e (Tan et al., 2012), and it is lower than the estimated result of 4.6TCO_2e of Norwegian University of Science and Technology (Larsen et al., 2013). College and university students, primary and secondary students’ daily life carbon footprints are the highest, with catering, bathing and daily electricity consumption accounting for 66% of the per capita carbon footprint of college and university students and 50% of the per capita carbon footprint of primary and secondary students.

The transportation carbon footprints of primary and secondary students are much higher than that of college and university students, which is related to the fact that primary and secondary students need to commute every day by buses, subways and private cars. Chinese colleges and universities are compact in layout and centralized in function, and most commodities and services are provided on campus. College and university students spend most of their time on campus, and the daily traffic travel rate is not high. When students need to go out, they often walk or cycle, and they take the school bus to travel between different campuses, so the transportation carbon emissions are relatively low. During the epidemic period, there was no transportation carbon footprint, and the carbon footprint related to daily life accounted for 63% of college and university students and 87% of primary and secondary school students, respectively. The carbon footprint of online learning accounts for 37% of that of college and university students and 13% of that of primary and secondary school students. The relatively low carbon footprint of primary school students may be related to the fact that the Ministry of Education stipulates that primary and secondary school students should spend no more than 150 minutes studying in the air classroom every day in order to protect the eyesight of young people.

4.2 College and university students' carbon footprints are significantly higher than before the epidemic outbreak, with catering contributing the most

The absolute carbon footprints of college and university students have increased by 29 percent according to measurement. It is because that Chinese campuses have compact layout and are centralized in functions. Staying at home reduces the transportation carbon footprint, the extra carbon footprint (due to electricity consumption, food wasting) of staying at home counteracts the reduction.

4.3 Carbon footprint consumption can be reduced by fitting the model of online education accounting for 60% and offline learning accounting for 40%

The reduction of learning carbon footprint is more obvious in the combination of online and offline education mode. The carbon footprint of learning is mainly derived from the electricity consumption of computers or smart phones, which effectively replaces the consumption of paper and textbooks in traditional learning. Students can choose to study in public spaces such as classrooms or libraries, then the higher the seat density of public space is, the lower the carbon footprint per person will be.

By changing the online teaching mode, we use complete online and complete offline education, these two extreme cases with reference to the latest Peking university network PBL learning mode, simulated combination mode of online and offline education in which online education accounted for 60% and offline education accounted for 40%. The results show that the per capita educational carbon footprint has a downward trend. At the same time, it is important to know that the research object of this study is the educational carbon footprint of individual students. We do not calculate the reduced operating energy consumption due to school closures during the epidemic.

4.4 Compared with foreign universities, Chinese colleges and universities' per capita carbon footprint is lower in terms of transportation, but it is much higher in terms of daily life (Eggleston et al., 2006; Fan et al., 2021; Güereca et al., 2013; Ranganathan and Bhatia, 2004; Tan et al, 2012; Wen, 2012; Xiao, 2015)

This is because Chinese colleges and universities have compact layouts and more centralized in functions, most of the commodities and services are provided on campus, and students spend most of their time on campus, so the daily traffic travel rates of teachers and students are not high. Most foreign universities do not provide accommodation on campus. Most students in foreign countries can only choose to rent an apartment near the university or in a community with convenient transportation. This part is often not included in the calculation of the carbon footprint of university life, which leads to the difference in statistical results.

5.0 Research Values

According to the Chinese experience and achievements during the epidemic, it is reasonable to predict that online education will be a regular educational mode in China and even to the word. Firstly, online education is poised for taking off. The achievements of basic education information construction over the years work as an important foundation to support carrying out this large-scale online education. Secondly, the online learning model is gradually recognized and accepted by the public. Thirdly, the unique advantages of online education complement the offline education in an optimized way. Fourthly, the support of national policies benefits the healthy development of online education market.

In this context, this study introduced the carbon footprint index, which is used to quantify the consumption of natural resources, into the field of education is an attempt of interdisciplinary integration. Through quantitative methods, the study measured the carbon footprint scales in three scenarios: complete online learning during the height of the epidemic, offline learning as the main mode and online learning as the supplement mode, and the combination of online and offline education prediction mode in the future. The study analyzed the carbon footprint of individual students and compared the data with international colleges and universities' indicators to describe the characteristics of China. However, this research is frontier and the data acquisition is limited, therefore this paper did not analyze the upstream and downstream situations, which means it did not include the carbon footprints of faculty and staff, and we did not investigate the situation of the online-offline transition period. Although we have much work to do in measurements in the future, this study is a meaningful exploration for the impact of online education on sustainable development in China. In the future, further investigation and research will be carried out to improve and revise the index system in order to obtain more scientific results.

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Bilibili Interactive Teaching Video — A Supplement to the Undergraduate Course on Operational Research

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Abstract

Purpose – With the rapid development of the video-sharing website, traditional classroom teaching has been supplemented to some extent. This paper aims to explore the influence of the video-sharing website on improving the teaching effect on the operational research course. In addition, methods for enhancing students' enthusiasm for learning and performance by the video-sharing website are proposed.

Design/methodology/approach – An experiment has been designed to demonstrate the effect of the video-sharing website on students' performance using 'Bilibili' with its property of a barrage. The course on operational research was uploaded. The advantages of the teaching method were analysed according to the background data and comments on the website. The students can fire the barrage while watching the video. All the audiences can respond by sending the barrages to each other, which is useful for geting the explanation for the question during the learning process.

Findings – Bilibili provides a teaching platform to communicate widely, like having a worldwide classroom. From a survey on the audiences, it was found that the students on different levels like to choose their own teaching speed or repeatedly watch a certain episode of the teaching video, due to the speed set and repeated play function. This kind of video-sharing website has removed the restraints in the classroom, and the role of the teacher has changed from being in a high position to becoming a sharer, so that teachers and students get closer to each other and the students can absorb knowledge more easily.

Originality/value/implications – This mode of learning allows students to study in a more relaxed way. Learning is like playing. The students' interest in learning can be stimulated to a greater extent by this interactive teaching mode. The communication method of barrages can make students braver in expressing their questions and ideas. Such learning in a video-sharing website provides a good supplement to traditional classroom teaching.

Keywords: Mediated learning communities, Video-sharing website, Interactive teaching

1 Introduction

The development of interactive internet technology provides a new platform for the advanced education. More and more online learning communities are coming out. People can set the learning task according to their own schedule regardless of time or place (Karich et al., 2014). Online learning communities can be divided into two types, one is developed by the schools for the internal students only, the other one is the open-access platform, which is accessible to all the users. The video-sharing website is one of the latter that offers new possibilities for the interactive teaching. Bilibili, a free video-sharing website, is widely used for its diversity and inclusivity. The barrage is one of its major features that offer people to communicate more freely and widely.

The operational research is a basic required course for the undergraduates in the subjects of transportation engineering, industrial engineering, supply chain management, computer science and systems engineering. It is widely used to solve complex problems in the real life, especially to improve and optimize the system efficiency. It has a certain difficulty in learning for the first-year and second-year university students. In this paper, the teaching effect via the video-sharing website (Bilibili) is studied through the operations research course.

2 Theoretical background

The advanced education increasingly adopts open-access online learning communities to strengthen teaching practices. Some massive open online courses (MOOC) are collaborated with schools, offering online learning opportunities and diplomas. Suter et al. (2021) pointed that MOOC had a good performance on a larger scale. Milligan et al. (2013) divided the people into active participation, passive participation and lurking and analized their participation experience in MOOCs. They found that the active people were the key group in MOOCs, who would like to create and share courses. The lurkings could gain benefits and feel satisfied, but there was no return for the community. Passive behavior indicated that they did not want to decide when and where to learn.

In addition, there are some video sharing websites that can also serve as platforms for online learning such as YouTube and Bilibili. Chen et al. (2012) found that 40 percent of the videos on YouTube were academically-oriented and the predominant language was english. Mcclean et al. (2016) studied the reflection of chemistry laboratory classes for year one students through YouTestTub, a YouTube clone websites for video sharing. They found that students liked to watch, evaluate and comment upon colleagues' videos. The use of videos could help college students to enter the early stages of the advanced education before they enrolled to the university. According to an industry report released by QuestMobile Research Institute in 2018, Bilibili ranked the first among the young people's favorite apps. A large number of official accounts of professional research institutions and universities have settled in Bilibili. Lü (2021) explored how to effectively carry out ideological and political education for college students through Bilibili.

3 Methodology

3.1 Bilibili

Bilibili, founded in June 2009, is a highly concentrated cultural community and video sharing platform for the young generation in China. It was originally a video website for the creation and sharing of Anime, Comic and Game (ACG) content at first. After more than a decade of development, it has built an ecosystem of high-quality content around users, creators and content. Now it covers more than 7,000 multi-cultural communities of interest.

Figure 1 The interface of teaching video in Bilibili

Teachers can apply to be the uploader at Bilibili for free. After the video uploaded by the uploader using the website, toolbox or APP and content checked by the system, the uploader can obtain the relevant data of video playback through the data center, such as the number of playback, the numbers of comments, interactive barrage comments, shares and favorate collections, etc. They can also obtain a portray of the users and the followers' profile. It is very helpful to better understand the characteristics of the audience, such as gender, age, region, favoriout video types etc.

3.2 Feedback data analysis of operational research course

The operational research teaching video for the undergraduate by our teaching group is taken as a case study. For the online teaching demand due to the COVID-19, we uploaded the teaching video to Bilibili in the spring semester of 2020 synchronized with the offline courses. The videos were recorded by Powerpoint with the sound and note recording by the teacher during the teaching. Now it can be taken into study how it performed in a year. The overview of the feedback data is showed in Table 1. The total number of the playback is 162,740, the number of barrage is 446, the number of video collection is 3,192. The data infers that the videos has been widely disseminated and has brought benefits to people from different areas. Compared with the traditional classroom teaching, around 30 students for each class, this way of learning can not only provide a learning platform for the students out of the school, but also enable more people to review the teachers' lectures. It is equivalent to improving the teaching quality from both the students and the teachers.

Table 1 Overview of feedback data of operational research

Play	Barrage	Comments	Shares	Collections	Like
162,740	446	541	1,036	3,192	2,791

The following analysis are addressed from two aspects: the video playback and the fan porfile.

(1) Increment of video playback

The number of the daily increasing views of video shows how the continues extent of attraction of the video. It can be inferred from Figure 2 that the operational research course has a longer appeal, still drawing nearly 400 views a day.

Figure 2 Increment of video playback from April 8th to 14th in 2021

(2) Fan profile

It can be seen from the feedback data that the number of fans is 3108 and the interaction activity is 5%, which means about 155 people have made likes, comments, barrage and other interactions. Fans come from neaaly all parts of China as shown in Figure 3. Among them, Shandong provience, Jiangsu provience, Guangdong provience and Beijing account for more than 8% respectively.

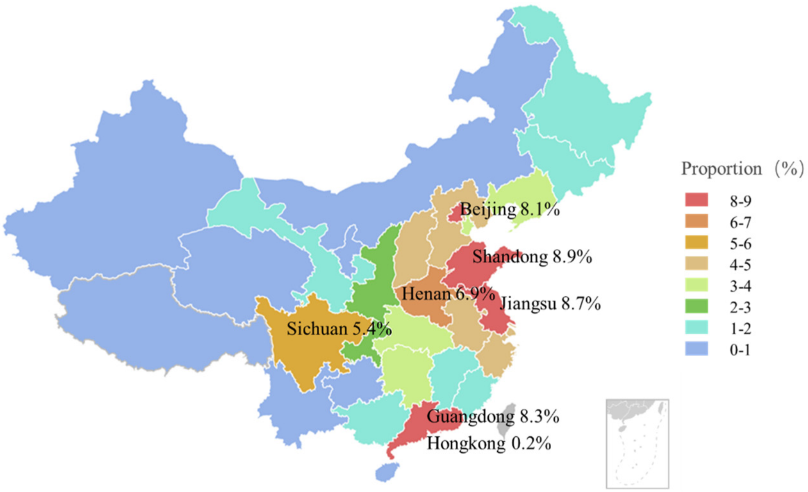

Figure 3 The geographical distribution of fans

Operational Research is a required course for undergraduate students, mainly for young people aged 17-25. It can be seen in Figure 4 that this group accounts for 40 percent of fans.

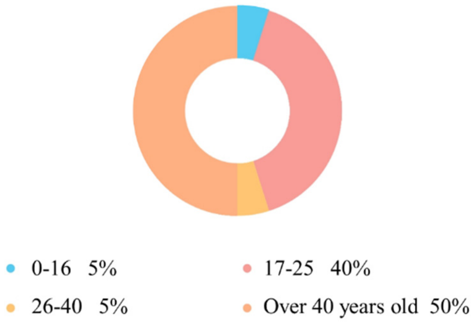

Figure 4 Age distribution of fans

Surprisingly, 50 percent of fans are over 40 years old. This shows that in addition to student groups, the videos placed on video-sharing websites attract a large number of groups. From the perspective of age, they may be teachers for this course, the experts in some other fields or people who want to supplement themselves by self-learning. This creates an environment for extensive learning and communication. The people across age groups can communicate through comments or barrage, which is more diverse than traditional classroom teaching.

3.3 Investigation data analysis

To further understand the acceptance and success of the videos, we randomly invited people who had seen the teaching video on Bilibili to participate in the survey.

A total of 222 questionnaires were sent out and 214 were valid. Respondents' satisfaction with the course videos averaged 8.08 out of 10.

The geographical attributes of the respondents are coincided with those of Bilibili fans, as shown in Figure 5. The factors of the widely popular of teaching on Bilibili can be evaluated through the questionnaire results.

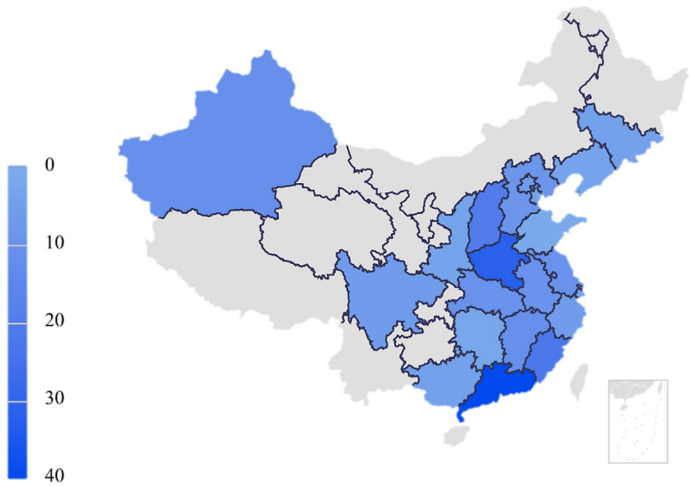

Figure 5 The geographical distribution of respondents

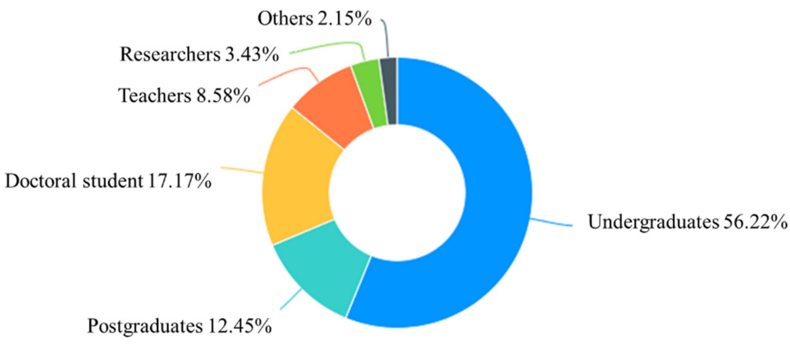

Figure 6 Occupations of respondents

Most of the respondents are students, including undergraduates, postgraduates, doctoral students, and a number of teachers and researchers, as shown in Figure 6. Occupation is chose for cross-analysis with other issues.

(1) Preference for speed and interaction in different occupations

How many the times and how about the play speed do the audience of different groups prefer to watch the courseware video? According to the results, about half of respondents prefer to watch operational research videos at normal speed. But there are about half of the respondents have a need for their own learning plan. In terms of the difference between occupations, for the users prefer 0.75 times play speed with a longer study time, most of them are the undergraduates, postgraduates and others (maybe high school students) choose, as shown in Figure 7. On the contrary, most of teachers use 1.25 speed, or even twice the normal speed. The characters of the researchers are the most balanced, probably because they comes from different special fields.

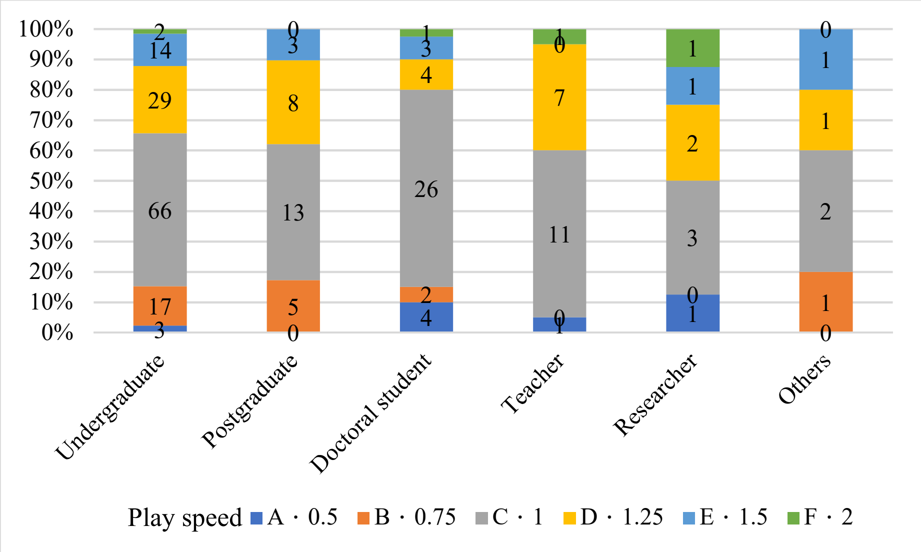

Figure 7 Cross-analysis of occupation and speed

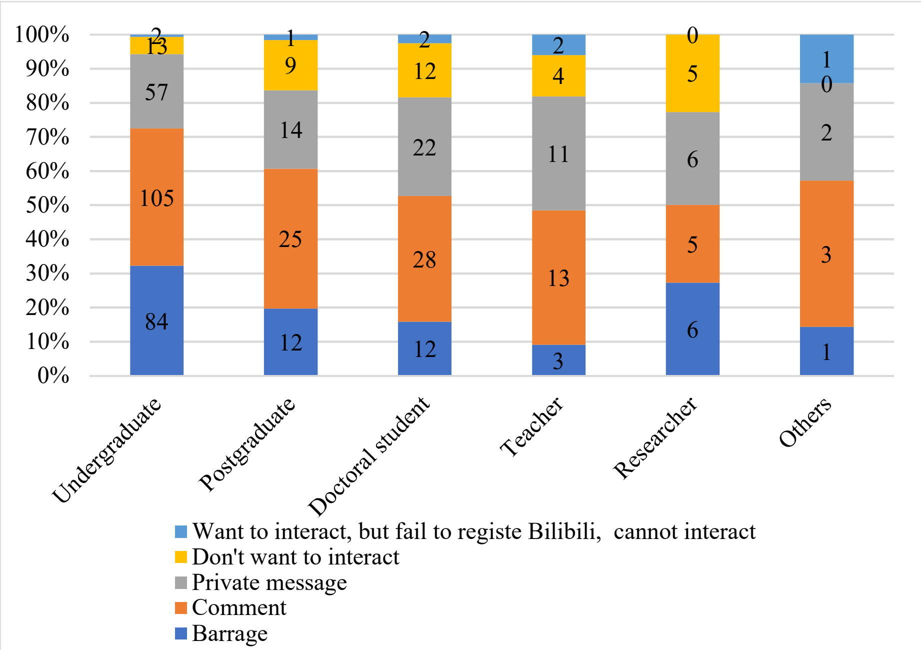

Figure 8 Cross-analysis of occupation and the mode of interaction

The respondents were also asked what kind of interaction they preferred. Commenting is the favorite interaction form among all occupations as shown in Figure 8. At the same time, barrage is an advantage for Bilibili in teaching, especially for the undergraduate students. More than 80 respondonts, accounting for 37% of the undergradustes prefer the barrage to any other interact for commuication. Neither the traditional teaching in the classroom nor the other online teaching can provide this function in real time. In general, Bilibili provides a new and popular way for teacher-student interaction, especially for the young generation.

(2) Preference for Bilibili or traditional class in different occupations

The survey also addressed on the teaching effects between the teaching in class and that on Bilibili. Most students prefer to study in Bilibili rather than in traditional classes, as in Figure 9. There are 81.2% of undergraduates think that study in Bilibili has a better effect for operational research course. A major part of the researchers think the learning effects for the two styles are similar, since they usually use the normal play speed on bilibili. For the teachers who follows our teaching video on bilibili, the attributes for the traditional teaching, the teaching on bilibili and the joint are on the average. It infers that not all the teachers are easily to adapt to the new teaching style and the communication website.

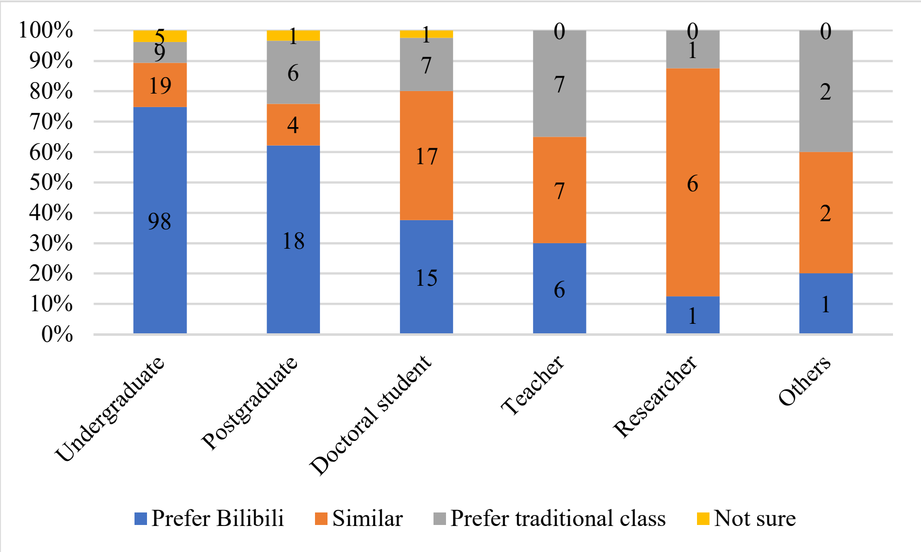

Figure 9 Cross-analysis of occupation and teaching mode preference

4 Conclusion

This paper analyzes the performance of video-sharing websites in teaching through the the operational research teaching videos uploaded on Bilibili. According to the feedback data on the system and the questionnaire survey on the audience, the acceptability of the people to learn operational research on Bilibili, especially for the undergraduates is verified. The conclusions are as follows.

(1) Video-sharing websites provide a platform for teaching that can enable people of different ages from all over the world to express their views on the same academic issues. It creats a variety and inclusive environment for self learning.
(2) Video-sharing websites provide a widely reviewed environment for the teachers. It can urge teachers to prepare more easy-to-understand explanation manuscripts to adapt to different groups. At the same time, teachers can get a variety of teaching feedback through the platform's data center. This can help the teacher to improve the teaching in the subsequent terms for the same course.
(3) Teaching on video-sharing websites is a major trend in the future, which can well avoid the defects of rigidity and prudishness in traditional classroom. However, it lacks the study process management and restraint for the students. So that it cannot completely replace the traditional classroom teaching. It is more suitable to play as the supplement of the traditional classroom teaching for the advanced education, especially for the foundation courses which are difficult for the students to understand at once. The playback and interactive comments can promote the teaching effect significantly.

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The Dilemmas of the Teaching Staff Construction of the Open University of China, Based on the Visualization Analysis of the Literature Indexed in CNKI

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Abstract

Purpose – Using the visualization analysis of the relevant literature indexed in the Chinese National Knowledge Infrastructure (CNKI) from several perspectives, this paper tries to reveal some prominent problems. The focus is on the teaching staff in the Open University of China during the transition period.

Design/methodology/approach – The research method in this paper is the visualization analysis of the relevant literature indexed in the CNKI. The basic steps are: 1. Typing in the keywords, collecting and selecting the valid sample data; 2. Using the CiteSpace service provided by the CNKI, the effective sample data is visualized and quantified to generate relevant charts and figures; 3. Illustrating the visualized data; 4. Analyzing the current academic research on the problems of the teaching staff, based on the analysis of the visualized data in the Open University of China, we try to reveal some new problems compared with the current research results based on the literature review.

Findings – This paper reveals some additional problems in teaching and the academic development of the teaching staff in the Open University of China from several perspectives. Firstly, since the process of teaching is separate from the process of learning in time and space, the relationship between teacher and student is distant. The sense of the teacher's professional happiness and achievement are not very high, so the effect of teaching and learning decline. Secondly, there are two main problems in the professional development of the teaching staff: the limited talent for teaching and the low teaching capability. Thirdly, teamwork efficiency is relatively low. Finally, the inequality in the traditional social evaluation system, academic evaluation system and educational policies has exerted some adverse effects on the teaching and academic development of the teaching staff in the Open University of China.

Originality/value/implications – From the perspective of research on the sample data collected from CNKI by using the visualization analysis method, this paper provides a new perspective for analyzing the current problems in the teaching and academic development of the teaching staff of the Open University of China.

Keywords: Open University, Open Education, Teaching Staff, Academic research, Bias

1 Introduction

With the continuous advancement of the education reform and innovation in China, as well as the rapid development of the high technology such as artificial intelligence, the Open University of China, which is in the period of transition and growth, is facing some new opportunities and challenges. Especially, the construction of teaching staff of the Open University of China is a crucial issue worthy of in-depth discussion.

Focusing on the construction of the teaching staff of the Open University of China during the transition period, this paper tries to reveal some additional problems in teaching and academic development of teaching staff in the Open University of China from several perspectives. Specifically, firstly, since the process of teaching and learning are separated from each other in time and space, the relationship between teacher and student is alienated seriously, and the sense of teacher's professional happiness and achievement are not very high, so the effect of teaching and learning are declined undoubtedly. Secondly, it is easy to find that there are two main problems in the process of the professional development of the teaching staff, namely the limited talent for teaching and the low teaching capability. Thirdly, it is not difficult to find the efficiency of teamwork is relatively low. Finally, the inequality being in the traditional social evaluation system, academic evaluation system and educational policies has exerted some adverse effects on the teaching and academic development of teaching staff in the Open University of China.

2 Method and Literature Review: A Visual Analysis Based on the Relevant Literature Indexed in CNKI

The research method adopted in this paper is the visualization analysis of the relevant literature indexed in CNKI.

2.1 The Source of the Sample Data

As this study belongs to Chinese localization research, the sample data are all from China journal literature database of CNKI. The field of the sample data is the open education research. In order to ensure the effectiveness, authenticity and authority of the sample data, sample data selected in this study were all from the highly authoritative journal databases in CNKI, including the Science Citation Index (SCI), Chinese Social Sciences Citation Index (CSSCI), Chinese Core Journal Database, Peking University Chinese Science Citation Database (CSCD) and the Engineering Index (EI).

2.2 The Collection and Selection of the Sample Data

In the CNKI journal database, the search scope was determined as the "academic journal", and the search was carried out according to the different topics without limiting the search time range. The latest search time was April 10, 2021, and a total of 626 results were retrieved for four times.

The details of the four retrievals are below: the first time, typing "Subject: Open University" AND "subject: faculty", a total of 360 results were retrieved; the second time, typing “Subject: Open University Teachers” AND “Subject: Open Education”, a total of 35 results were retrieved; typing “Subject: Open University Faculty” for the third time, a total of 86 results were retrieved; typing “Subject: Open University” AND “Subject: Open Education” AND “Subject: Teachers” for the fourth time, a total of 145 results were retrieved. After screening and eliminating invalid sample data, 110 valid sample data were obtained. And then, the sample data is taken to be visualized to generate new types of data on charts and figures.

2.3 The Analysis of the Sample Data

Based on the figure data, the sample data are respectively explained from the perspectives of the trend in publications throughout the year, the distribution of the research topics, the distribution of the journals and the distribution of the research institutions to depict the basic situation of the current research in the Chinese academic field.

The Analysis from the Trend in Publications throughout the Year

The effective sample data obtained in this study covered the years from 1996 (the whole year) to 2011 (the first half year), forming a chart of the trend in publications throughout the year with time as the horizontal axis and the annual publication volume as the vertical axis, as shown in Figure 1.

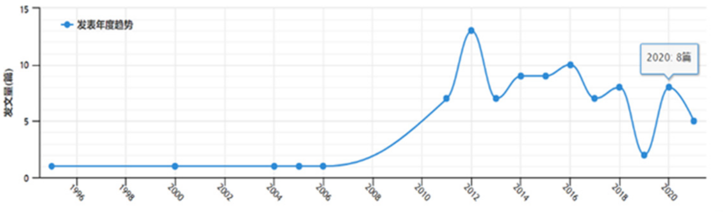

Fig. 1. The trend in publications throughout the year

Source: CNKI

From 1996 to 2006, the annual number of papers published in journals associated to this research topic was basically the same. From 2006 to 2012, the annual number of papers published in journals related to this research topic showed an increasing trend year by year and reached a peak in 2012. The number of journal papers published before and after the peak in 2012 (2011 and 2013) was basically the same. From 2013 to 2016, the annual number of papers published in journals related to this research topic increased gradually. From 2016 to 2019, the annual number of papers published in journals related to this research topic showed a steep trend of decline, and the lowest peak appeared in 2019. From 2019 to 2020, the number of journal papers published showed a sharp increase, which was consistent with the number of journal papers published in 2018. Since 2020, it has shown a downward tendency.

The peak of 2012 was since the Open University of China was officially inaugurated in the Great Hall of the People on July 31, 2012, which initiated the important journey of the transformation of the China Radio and Television University to the Open University of China. Hence, the issue of the construction of the Open

University's teaching staff drew extensive attention from the academic field. Obviously, the emergence of the lowest peak in 2019 shows that the academic field pays less attention to the issue of the construction of the teaching staff of the Open University of China, which just shows that the open education in the transition period has exposed many problems that need to be solved in addition to the construction of the teaching staff.

In 2019, COVID-19 virus spread around the world. Affected by the COVID-19 epidemic, online education mode has become a mainstream education method generally chosen by schools at all levels and after-school counseling institutions in China during the epidemic period. While the issue of the construction of teaching team online has been gradually pushed onto the hot topic list, and also the same issue in the open education has also been aroused the attention of the domestic academic field again.

Depending on the trend in publications throughout the year, the domestic academic circle had paid increasing attention to the issue of the teaching staff construction of the Open University of China in the past decade. However, the focus of research is very unstable with the emergence of some significant events.

The Distribution of the Research Topics

Based on the effective sample data and the visualization analysis function of CNKI, the distribution chart of relevant research topics with the research topic as the horizontal axis and the number of literature as the vertical axis is generated, as shown in Figure 2.

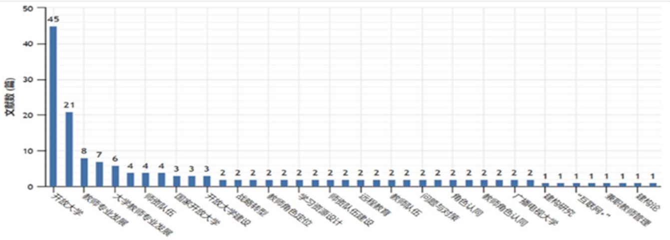

Fig. 2. The distribution of the research topics

Source: CNKI

The articles related to the issue of the teaching staff construction of the Open University of China in the transition period mainly include the following aspects: the professional development of teachers, the professional development of university teachers, the teaching staff, the teaching staff construction, the role positioning of teachers, the role identification of teachers, the management of the part-time teachers, the construction of the Open University of China, etc. It can be seen from the number of the published journal articles that the academic circles in China do not pay much attention to the teaching staff construction of the Open University of China, and the high-quality research achievements are relatively lacking.

The Distribution of the Journals

Based on the effective sample data and the visualization analysis function of CNKI, the distribution of the journals is shown in Figure 3, with the journals as the horizontal axis and the number of articles published in the related journals as the vertical axis, as shown in Figure 3.

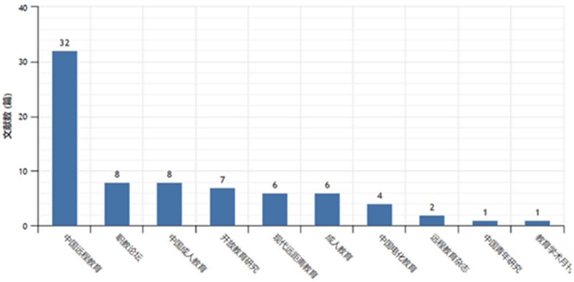

Fig. 3. The distribution of the journals

Source: CNKI

Papers mainly related to this study, published in these journals are as follows: Distance Education in China, Journal of Vocational Education, China Adult Education, Open Education Research, Modern Distance Education, Adult Education, China Educational Technology, Journal of Distance Education, China Youth Study, Education Research Monthly. Among them, compared with other journals, the number of papers published on the issue of the teaching staff construction of the Open University of China in the Distance Education in China is 32 in total, which makes it become the typical journal with related research on this topic. However, compared with other research topics included in the Distance Education in China, the number of papers published on the subject of teaching staff construction of the Open University of China are not optimistic, and to some extent, most of the papers around this topic lack innovation in research hypotheses and research ideas and research methods.

The Distribution of the Relevant Research Institutions

Based on the effective sample data and the visualization analysis function of CNKI, the distribution of the relevant research institutions related to this study was generated with research institutions as the horizontal axis and the number of papers as the vertical axis, as shown in Figure 4.

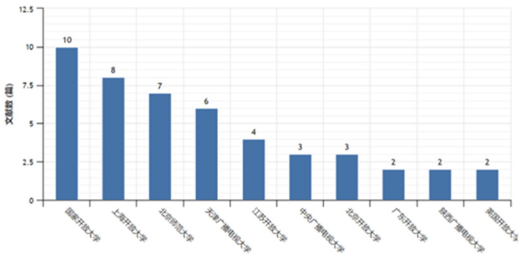

Fig. 4. The distribution of the relevant research institutions

Source: CNKI

The relevant research institutions are the Open University of China, Shanghai Open University, Beijing Normal University, Tianjin Radio and Television University, Jiangsu Open University, China Radio and Television University, Beijing Open University, Guangdong Open University, Shanxi Radio and Television University, Open University, UK. In terms of the number of publications, the research institutions with more than five publications are the Open University of China, Shanghai Open University, Beijing Normal University and Tianjin Radio and Television University. Among them, Chinese scholars from the Open University of China have taken the most achievements in this field.

2.4 An Analysis of the Current Situation of the Research in this Field in China

The analysis of the current situation of the research on the issue of the teaching staff construction of the Open University of China is conducted from two perspectives. Specifically, the overview of the current situation of the research in this field in China is given before a literature review on this topic in this field.

Overview of the Current Situation of the Research in this Field in China

The domestic academic research on the issue of the teaching staff construction of the Open University of China in the transition period has not yet formed a relatively large study scale and is still in the primary stage. From the perspective of the research theme and research perspective, the current research is relatively extensive and lacks the intensive research. In terms of the research method, the qualitative research is more than the quantitative research. From the perspective of the research achievements, the number of relevant academic achievements, of specialized research institutions carrying out the relevant research, of high-quality research achievements are rather small. From the perspective of the relevant Chinese scholars, there are few Chinese scholars who have been engaged in the research of the teaching staff construction of the Open University of China for a long time.

Literature Review of the Research in this Field in China

At present, the domestic journal articles published in this field mainly focus on discussing the connotation and structure of the teaching staff construction, the better ways to build better teaching teams, the teaching quality as well as the identity construction of the teaching staff of the Open University of China.

From Fujian Radio and Television University, Feng (2015) in his article "*An Analysis of the Quality of Teaching Staff Construction in Transition from the RTVU to the Open University*" put forward some new requirements in the teaching staff construction with high quality in the Open University of China, and pointed out that the challenges and solutions in the construction of teaching staff of the Open University of China during the transitional period. Wu (2016), from Jiangsu Open University discussed the main problems restricting the faculty construction in his article "*Prominent Problems and Countermeasures Restricting the Teacher Development of the Open University*".

Tang (2014), from Shenzhen Radio and Television University, in his article "*Reflections on the Construction of Teachers' Team in Colleges of the Open University*" pointed out that the main problem of the teaching process of the Open University of China was that the number of the competent teacher is relatively small.

From the perspective of the construction of the part-time faculty in the Open University of China, Ni (2017), from Nanhui Branch of Shanghai TV University defined the role of the part-time faculty in the Open University of China as "five dimensions" in her article "*Exploring the Faculty Transition of Part-time Teachers in Open University*", that was, service, management, skill practice and academic research.

About the Open University teachers' position, role, career development, Feng & Liu (2016) in their article "*Some Issues on the Professional Development of the Open University Teachers: Orientation, Roles and Responsibilities and Career Development*" discussed the professional orientation and problem of how to construct the role identity of the teaching staff in the Open University of China and put forward that the professional development of teachers should conform to the characteristics of the Open University of China. As for the further research of the role identity construction of the Open University's teaching staff, Zhang & Zhu (2018) co-authored the paper "*A Case Study on the Construction of the Role Identity of the Open University Teachers: Sociological Symbol Interaction Theory and Construction Perspective*". Through in-depth interviews with four Open University teachers, the paper discussed the issue of the identity and role identity of the Open University teachers. Papers on the issue of identity construction also include "*The Recognition of Teachers' Identity: A Theoretical Interpretation*" (Rong, 2019), "*Analysis on the Ability Structure of Teachers in Regional Adult Colleges and Universities under the Background of Life-long Education*" (Ding, 2012), and "*Research on the Professional Development Mechanism of the Open University Teachers in the "Internet +" Era*" (Chen, 2017), etc.

As for the research on the teaching capability of the Open University's teaching staff, the outstanding research achievement is the paper co-authored by Feng & Liu (2017) from the Open University of China. In their article "*On the Standards of Teachers' Teaching Competence in the Open University*", they mainly used two research methods, literature review method and interview method to conduct in-depth analysis on the sample data and constructed some standards to measure the teaching capability of the Open University's teaching staff. Yan & Sun (2012) pointed out the vital importance of improving teacher's teaching capability and competence in providing supporting service in their co-authored paper "*Some Reflections on the Professional Development of Distance Education Teachers*".

As for the research on the academic career development of the Open University's teaching staff, Sun (2015) analyzed the opportunities and challenges of the academic career development of the teaching staff working in the Open University of China in his article "*The Academic Career Development of the Open University Teachers in China under the Background of Being as a New University*".

As for the research on the transformation of the Radio and Television Universities to the Open Universities, Yuan (2018), as the president of Shanghai Open University, pointed out in her article "*Building the First-class Open University with Chinese Characteristics: Objectives and Strategies*" that the construction of the Open university should take a new approach.

About the relationship between the Open University of China and the China Radio and Television University, Hao (2013), as a member of the National Education Advisory Committee, in her article "*Reflections on New University of China—The Open University*", pointed out that the Open University is not the renaming of the Radio and Television University, but a profound strategic transformation.

As to whether the Open University of China should pay more attention to its characteristics or pay more attention to its academics like ordinary universities do, Xu

& Wang (2018) analyzed "1+5" Open Universities as the research samples in their article "*Open University: Academic or Application*", suggested that the characteristics instead of the academics of the Open University of China should be highlighted.

3 Dilemmas in the Process of Teaching and Academic Development of the Teaching Staff of the Open University of China

Basically, there are four major problems in the process of teaching and academic development of the teaching staff of the Open University of China. They can be listed as follows: 1. It is easy to lead to the gradual decline of the teaching and learning effect under the circumstances of the occurrence of the separation between teaching and learning as well as the estrangement of the relationship between teachers and students; 2. The limited talent for teaching art and the deficiency of the teaching capability; 3. The burning questions of constructing and adapting into the various role identities of the teaching staff working in the Open University of China; 4. The existence of inequality in the traditional social evaluation system, academic environment and educational policies.

3.1 Because of the Separation of Teaching Time and Space: The Attenuation of Teaching and Learning Effects in the Estranged Relationship between Teachers and Students

It is obvious to see that the biggest difference between the open education and the ordinary higher education lies in the different choice of teaching mode in the teaching situation. Basically, it is mainly reflected in whether teachers and students can conduct simultaneous, same-place and face-to-face communication. As Chen (2017) pointed that "the form of distance education in the Open University of China is different from the face-to-face education in ordinary colleges and universities". That's to say, teaching in ordinary universities is mainly taught in fixed places and teachers can communicate with students all the time and get real, effective, and timely teaching feedback. However, "the real challenge of distance learning is to design, develop and deliver learning content in different time and space environments without direct feedback from the learner" (Chen, 2017).

Based on the characteristics of the open education, there is a separation of learning time and place among teachers and students in the teaching process, and it is almost impossible for teachers and students to truly conduct barrier-free and face-to-face communication. Hence, in this situation, there will be undoubtedly a kind of seriously negative impact exerted on the teaching effect and learning effect. To some extent, in the absence of sufficient and effective teaching situations, it is therefore difficult to establish a stable emotional connection between teachers and students, so it is hard to establish teachers' authority in the minds of students. Similarly, students' trust in teachers is also not easy to be constructed to a certain extent. Under the circumstances, it is likely to cause students to question teachers' professional ability, classroom management ability, problem solving ability, academic ability and communication ability because of the lack of authority of teachers in the classroom, thus, perhaps to result in a negative impact on students' learning effect to some extent. Moreover, influenced by various factors including teaching environment, technological errors, indirect teaching feedback may increase the difficulty in the assessment of the teaching feedback result. In addition, the separation of teaching time and space in the open education not only exists between teachers and students, but also exists in the interactive learning between students and students, as well as the relationship between students and the use of learning materials. In other words, “the Open University teachers are still working to overcome the interaction delays between learners and teachers, learners and learners, and learners and learning materials caused by the separation of time and space between teaching and learning” (Chen, 2017).

As is well-known, in addition to the face-to-face teaching, the teaching mode in the open education mainly includes two common modes: video broadcast and live broadcast. To be specific, recording and broadcasting basically break away from the teaching situation of constant interaction and face-to-face communication between teachers and students, and there are many variables between teaching and feedback, “Learners cannot directly obtain knowledge and skills from teachers face to face, and teachers cannot directly obtain feedback on learning effects from learners’ facial expressions, subtle eyes and body movements” (Chen, 2017). As students can only learn by watching videos, it is almost impossible for learners to communicate and discuss with each other about the learning content. Compared with the video broadcast, the teaching effect of live broadcast class is better than that of video broadcast class. Besides, in a study with the Open University’s faculty identity research, a teacher said in an in-depth interview:

“Now I feel like I have come from the background to the front of the stage. Not only do I have to give lectures to hundreds of students, but I also must answer questions by phone, E-mail and so on. Since I became an online teacher, I seem to have no Sundays, and the time spent online every day has doubled” (Zhang & Zhu, 2018).

Obviously, compared with the form of teaching face-to-face in the ordinary colleges and universities, no matter the live broadcast or video broadcast in the open education, it is easy to cause the time and space dislocation between teachers and students, students and students, students and learning materials, resulting in the decrease of students’ learning effect. At the same time, this means commonly used in the distance education will undoubtedly increase the working pressure of teachers in the teaching process, affect the gain of the sense of teachers’ professional happiness, and thus may drew a negative impact on the teaching effect.

3.2 Limited Talent for Teaching Art and the Deficiency of the Teaching Capability

Teaching is both a sort of technique and a piece of art. In the process of teaching, teachers are not only served as the knowledge transmitters and knowledge creators, but also as skilled performers. Good teachers with outstanding capabilities not only have to accumulate teaching experience in the long-term teaching practice, but also have certain talent for teaching, which makes teaching closer to a unique piece of “performing art”. It can be said that teachers are more likely to deliver a good course, and more likely to be loved by students because of their talent in teaching, sufficient teaching experience and skilled use of teaching techniques. Therefore, the level of teaching art, the capability of teaching as well as the skills of managing teaching technics will undoubtedly exert a great influence on the teaching effect and students’ learning effect.

"The Open University of China, as a new type of university without walls, adheres to the philosophy of openness, responsibility, quality, diversity and internationalization and strives to meet the diverse and personalized learning needs of the people" (Feng, 2015). Compared with the education happened in the ordinary universities, the open education has higher requirements on teachers' teaching capability, which depends on the nature and characteristics of the open education. Teachers working in the Open University of China, therefore, should not only have the basic teaching skills, including capability to manage suitable teaching language according to various teaching situations, blackboard writing skills, ability to create different types of teaching situations, ability of classroom management, ability of emotional management, good communication skills, ability to deal with emergencies, time management skills, etc., but need to possess some other teaching abilities required to cater to the teaching activities in the distance education, such as the ability to design a course and to build teaching resources, capability to use well techniques in the teaching process, performance ability, team building ability, outstanding communicating and coordinating ability, etc. That is to say, "the unique teaching mode of distance and open education require distance education teachers not only to possess the basic quality of traditional education, but also should have the unique multi-dimensional capabilities" (Li, 2011).

However, the limited talent for teaching and low-level of using the teaching techniques and inadequate teaching capability have become the stumbling blocks to the teaching staff construction in the Open University of China. Worse still, encountered with the complicated and routine work, most teachers in the open education gradually lose time and energy to improve their comprehensive teaching ability and level. At the same time, the situation of the groups of students also has a certain degree of impact on the improvement of teachers' teaching psychology and teaching capability. Naturally, excellent teachers who are highly skilled and talented have become a scarce resource in the Open University of China. Thus, how to improve the teaching capabilities and skills with the characteristics of the open education has also become a very big dilemma for teachers who need to step out of in the Open University of China currently.

3.3 Dilemma of Constructing and Adapting into the Various Role Identities of the Teaching Staff Working in the Open University of China

With the in-depth development of science and technology, the Open University of China has made a significant improvement in so many aspects. However, as the learning characteristics of the target group of the Open University are personalized, the learning content and process are more and more convenient, clear, personalized, and technical, the role identity of the Open University teachers as well as the content of their work and responsibilities they need to undertake are also in line with them. To some extent, the maturity of teachers' role identity in the Open University of China will directly affect the teaching quality.

"Professional identity is a kind of social identity, which involves two aspects: professional cognition and professional emotion" (Lu & Wang, 2020). The premise for the construction of the teachers' role identity is the preliminary construction of the relevant professional cognitive structure. "Occupational cognition includes the cognition of occupational attribute, occupational value, occupational role, occupational function and so on" (Lu & Wang, 2020). After the completion of the construction of the vocational cognition structure, with the deepening of the degree of the cognition of the occupation, the perceptual factors will gradually be constructed, and then form a certain degree of vocational emotional cognition structure, including occupational belonging, occupational happiness, occupational anxiety, etc. Professional identity, based on professional cognition, is mainly manifested as a kind of identity of professional belonging and other professional emotions. "Professional identity is mainly a process of professional cognition. Based on professional cognition, it is possible to generate professional emotion and sense of belonging, and finally form professional identity" (Lu & Wang, 2020).

The special concept of the Open University exerts a profound impact on the construction of teachers' professional identity. Compared with the teachers working in the ordinary universities and colleges, teachers working in the Open University of China have to construct more diverse identities and improve their coordinating ability in a teaching team. Just as Li said, "teachers act as the imparter of knowledge, the developer of learning resources, the designer of teaching activities, the instructor of learning process and so on" (Li, 2011). Therefore, the essence of the Open University of China determines the basic characteristics of the Open University teachers' teaching practice. Teacher working in the Open University of China is no longer just served as a "opinion leader", but a "guide", a "team member", a "resource developer", and he or she had better to make the conversion between different professional identities come into being in order to adjust themselves to various types of teaching situation and working situation.

However, since there are many problems in the process of the constructing teachers' identity, and it is also hard for teachers to accommodate themselves to some new identities, and thus it easily that the dilemma of identity construction, to some extent, would have an adverse effect on many other aspects such as affecting the working efficiency of the teaching team. Under the context, it is how teachers working in the Open University of China should construct their working identities smoothly and how to ensure the various identities exert an optimistic effect that are two typical burning questions.

3.4 The Existence of Inequality in the Traditional Social Evaluation System, Academic Environment and Educational Policies

The Open University of China is a public institution directly under the Ministry of Education of the People's Republic of China. With the support of modern information technology, the Open University of China integrates academic education with non-academic education and implements distance and open education. According to relevant regulations and policies, "institutions of higher learning belong to the public institutions engaged in public welfare services, and their faculty and staff are supported by national finance" (Wu, 2016). The Open University of China belongs to the sequence of institutions of higher learning, so the personnel management of the Open University of China must be performed in strict accordance with the relevant national regulations. However, there are notable differences between the Open University and the ordinary universities in many aspects. As a new type of institution of higher learning, the Open

University of China is under a lot of pressure while its uniqueness has formed a kind of coercive mechanism for deepening education reform and innovation.

First, the orientation and characteristics of the Open University of China make the teachers working there have to undertake a lot of complicated affairs, so that the time and energy for doing academic research will be reduced; adding in the huge number of students and the insufficient number of teachers, thus, the direct result under such a worse condition is that the amount of work undertaken by the leading teachers, responsible teachers and tutoring teachers only increases. In addition to the teaching assignment, they are also required to undertake various kinds of routine tasks. "It is normal for the Open University teachers to play multiple roles, which is not conducive to the development of specialization" (Feng & Liu, 2016). Besides, compared with the teachers working in the ordinary colleges and universities, the Open University teachers' scientific research work has not been included in the total workload, and under the numerous transactional works, time to doing academic research is less and less, and the pressure from the academic research becomes bigger and bigger, and then the development space of the academic career for teachers is gradually narrowing. In an in-depth interview, a teacher interviewed said,

"This place requires us to act as the organizer. However, I think that as a PhD graduate who has been involved in professional development, we should focus on professional development, so I am very anxious. I always think that teaching and research should be the main theme, while the rest are sidelined!" (Zhang & Zhu, 2018).

Therefore, how to do scientific research in the complicated affairs has become one of the major dilemmas in the professional development of the Open University teachers.

Secondly, as the traditional social evaluation system still works all the time, therefore, it also works in evaluating the capability and social reputation of the teachers working in the Open University of China. People who have not transformed their traditional concept easily tend to regard the Open University of China as a "second-class university" among ordinary institutions of higher learning, so the society's evaluation towards the teachers' capacity and reputation who are working at the Open University is unfair. On this basis, a discriminatory social cognitive atmosphere is gradually formed. This kind of social culture not only directly affects the evaluation of the academic achievements of the teachers who are working at the Open University, but also has a serious negative impact on the attainment of the sense of professional happiness. Importantly, how to change this kind of social cognition culture with prejudice and discrimination and how to make the teachers working in the Open University of China respected and recognized by the society are not only the difficult problems in the professional development of the Open University teaching staff, but also the important aspects of the deepening educational reform in the Open University.

Finally, this kind of discriminatory social culture is not only manifested in the public's doubt on the competence of the teachers working in the Open University of China, but also in the academic research environment. As the Ministry of Education classifies the Open University as an adult institution of higher learning, the Open University is not eligible to apply for some teaching and research projects only for ordinary institutions of higher learning. Under this academic research system, there are few high-quality research achievements. As Wu (2016) said,

"The Open University teachers are very difficult to have high level of academic results. When applying for promotion of professional title or competing for other scientific research projects at the same time with their counterparts in ordinary colleges and universities, the Open University teachers often lack experts' recognition because of the identity of the Open University or the difference between the Open University and ordinary universities. The Open University teachers are often in a state of being marginalized or disadvantaged".

4 Conclusion

The Open University of China, as a new institution of higher learning with a large system, needs to be further defined and discussed. The unique characteristics of the Open University not only form a coercive mechanism for deepening the reform of the educational system and mechanism, but also make it bear the pressures from the educational system, the social environment, and the academic research system and so on.

As for the difficulties of the teachers' professional development in the Open University of China, there are at least four aspects. Basically, teaching and learning are kept separate from each other in time and space, and the relationship between teachers and students is estranged. Online teaching model increases teachers' workload, which not only weakens the teaching and learning effects, but also affects the attainment of teachers' professional happiness. And, the Open University teachers should not only have the same basic teaching ability as those in ordinary institutions of higher learning, but also have the more teaching ability in line with the teaching characteristics of the Open University, including the ability to design a course and to build teaching resources, capability to use well technics in the teaching process, performance ability, team building ability, outstanding communicating and coordinating ability, expression management ability in front of the camera, etc. However, the limited talent for teaching and the low level of teaching capability have become the stumbling blocks restricting the professional development of the Open University teachers. Importantly, the Open University teachers' role identity is more diverse, which requires teachers' teamwork ability to be higher. In order to improve the teaching quality, it is necessary to build a teaching team which is guided by the chief editor and the lecturer, dominated by the presiding teacher, supported by the responsible teacher, guaranteed by the tutoring teacher. However, there are many problems that may directly result in the problem of the inefficiency of teamwork. Besides, the orientation and characteristics of the Open University make the faculty of the Open University have to undertake a lot of complicated affairs, so that the time of scientific research has to be reduced, and the development space of the faculty's scientific research career is gradually reduced. The cognition of the whole society to the teachers of China Central Radio and Television University has a direct impact on the cognition of the whole society to the teachers' situations of higher learning, and the social evaluation on the ability of the teachers who are working in the Open University of China is also unfair. This kind of shared culture with discriminatory color is not only manifested in the public's doubt on the faculty ability of the Open University of China, but also in the environment of the academic research system. Encountered with those problems, all members of the Open University of China need more courage and consciousness of innovation to step out of those dilemmas.

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Research on College English Teaching from the Perspective of Ecological Linguistics

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Abstract

Purpose – With universal English language education in China for the past decades, the college students have acquired knowledge of the language at different levels after years of studying it. However, there exists a common phenomenon that most of them lack the ability to use the language and cannot conduct smooth intercultural communication. Researchers from different disciplines have tried to find a solution to this problem from different perspectives such as linguistics, pedagogy or brain science, but the problem has still not been solved effectively. Ecological linguistics focuses on the dynamics and systematicness of language learning, which provides a new perspective for research on language teaching and theoretical support for the construction of a more positively developed model of language teaching. This can provide a certain enlightenment for changing the current situation of college English teaching in China.

Design/methodology/approach – In terms of method, this study involved a literature review and inductive analysis.

Findings – From the perspective of ecolinguistics, this research regards the language teaching and learning process as a micro-ecological system, and conducts a comprehensive and dynamic investigation of English teaching. The interaction among learners, teachers, language and the learning environment in the system is studied from multiple perspectives. The ecological design of English teaching is carried out from the aspects of teaching objectives, teaching contents, teaching methods and a teaching evaluation system, so as to improve college English teaching methods and the efficiency of college English learners.

Originality/value/implications – Ecolinguistics considers the ecological environment of language comprehensively and regards English teaching as a dynamic ecosystem. In this system, teachers and students are the subjects of activities, with English language as the carrier, and Chinese and Western social culture as the living environment. All the elements in the system are interrelated. The sustainable development of the system needs an appropriate ecological environment, namely a classroom environment, a campus cultural atmosphere, a social cultural atmosphere, and policies and regulations. In addition, teachers and students need to give full play to their active initiatives. Teachers should guide students to choose their learning content and methods independently, help them to solve learning problems independently, and regulate their learning process. Students should participate actively in language teaching activities rather than just receiving knowledge from teachers passively. Only in such a dynamic system can students put what they have learned into practice and improve their ability in intercultural communication.

Keywords: ecolinguistics, college English teaching and learning, evaluation system

1 Introduction

Ecology, originated in Greek, was first proposed by the German biologist Ernst Haeckel. It refers to the overall science of studying the complex relationship between organisms and their surrounding organic and inorganic environments. In the late 1920s, western scholars introduced ecology into the field of education. In 1932, American scholar Willard Waller put forward the concept “Ecology of Classroom” in his book *sociology of teaching*. In 1972, Einar Haugen, a Norwegian linguist, put forward the concept “Language Ecology” in his article *Ecology of Language*, which mainly focuses on three aspects: language, language use and social environment. In 1976, Lawrence Creming, president of Columbia Teachers College in the United States, proposed the term “Educational Ecology” in his book *Public Education*. The ecology of education refers to the science of using ecological methods and principles to explore educational laws and study educational phenomena. Subsequently, Eggleston(1977), Bronfenbrenner(1979), Goodlad(1987) have studied educational resources, school development, and human beings. The research on behavior and ecological environment has greatly expanded the research scope of ecology of education. Atkiss, Burns(2011) based on the principles of ecology, explores the problems related to human growth and social environment, the utilization of resources inside and outside the school, and the development of schools, aiming to realize the in-depth development of ecology of education in application field.

At the end of 1980s, Chinese scholars began to study ecology of education. Ecology of education has developed rapidly since the 1990s. Based on the principles of ecology, it analyzes the causes of various educational phenomena, the relationship and effects between education and the surrounding environment, and then reveals the rules and trends of education development. Overall, the research mainly involves five aspects: (1) ecological research on foreign language teaching, including the reform of teaching methods, teaching modes, teaching evaluation and teaching design. For example, based on the theory of ecological linguistics, Zhu Yuncui(2017) constructed an ecological model of college English teaching; (2) discuss foreign language education in China from a macro perspective. For example, Wang Shouren(2013) calls for the construction of a harmonious ecological language from a macro ecological perspective to improve the quality of foreign language teaching in China. Wang Jin and Jin Nana(2018) discussed the role of English in global communication from the perspective of ecological linguistics; (3) ecological research on the professional development of foreign language teachers. Liu Yayan(2015) deeply analyzed the professional development of foreign language teachers based on ecological principles; (4) the ecological study of foreign language courses and college English classroom teaching from the perspective of ecolinguistics(He Fangzhi, 2016). Starting from the current situation of college English teaching reform, Xu Qihao(2018) constructed college English curriculum space from the macro and micro levels by using the theory of ecological education. As a new subject, ecology of education examines the interaction mechanism between ecological factors of education and the multiple educational environment from a new perspective, providing a theoretical foundation for the balance and coordinated development of the educational ecosystem.

1.1 Ecology of Language

In the *Ecology of Language* (1972), American linguist E. Hogen defined the concept of “linguistic ecology” as the study of the interaction between any specific language and the environment, and drew a metaphorical analogy between linguistic environment and biological ecological environment, which marked the origin of ecological linguistics. Ecolinguists believe that language and its existence in the real world is a dynamic process of reciprocal interaction, and one of its ecological characteristics in language acquisition is “salience” , which refers to the collective, complex and transcendental phenomena of a complex system under the conditions of some simple rules of interaction. Language is a complex system formed by the ecological interaction between the people with the desire to communicate and the world being discussed. People who support the theory believe that language learning and using is a complex and dynamic process in which multiple elements highlight at various levels.Language development and use are interacted between the language user and the environment language users live.

This corresponds with the views of social and cultural theory.The core idea of sociocultural theory is that the mental language process of language learners is inseparable from the social environment of language learners. For language learners, the process of language acquisition is a process in which language learners actively participate in meaning construction in the process of social and cultural communication(Niu Ruiying, 2007).Therefore, language learning is a social activity with social attributes first, followed by individual behavior. In this social activity, language learners and language “instructors” (including parents, teachers, and people around them) are the constructors of the learning environment, responsible for selecting learning objectives and operating specific learning processes.

1.2 The essence of English teaching from the perspective of ecological linguistics

Ecolinguistics takes language learning as a micro ecosystem and studies the interactional factors among learners, language teachers and language in the system from multiple perspectives and language learning environment, and also its influence on language acquisition. In other words, English teaching is no longer a simple teaching behavior, but a language teaching ecosystem. In this ecosystem, the main factors are: teacher-centered language professors, language teaching and learning environment in a specific language ecological environment, student-centered language learners, and English language culture. Learners learn English culture and language knowledge through English language, and interact with various elements in the system. The process of English teaching from the perspective of ecolinguistics is the micro-system of English language knowledge and cultural communication constructed by language teachers and language learners in the dynamic interaction process of teaching. In the process of the system construction, language teachers pass on language knowledge and cultural knowledge to the language learners; language learners acquire and consolidate language and cultural knowledge by participating in the construction of systems. The process of English learning is as follows: under the guidance of language teachers, the learners acquires English language and cultural knowledge and adapts to the English cultural communication mode through the communication and interaction with the language teachers and other learners in a specific language ecological environment. Learners not only learn language knowledge, but also participate in the construction of micro English cultural system, promoting both knowledge and cultural literacy. Therefore, they tend to have new talents on the requirements of global economic integration. Ecological English teaching is a dynamic and unified process including teaching objectives design, creating ecological teaching environment and adopting ecological teaching methods. For the learners, it is a process of adapting themselves into English culture in a specific culture context.

2 English teaching design from the perspective of ecolinguistics

From the perspective of ecolinguistics, English teaching mode should combine English teaching, language culture, language learning environment and learners' psychological environment organically, so as to construct a comprehensive and harmonious ecological language teaching mode. Ecological language teaching mainly has two interactive levels: first, the teachers adopt the teaching mode that the learning subject can cooperate, and guide the learners to consciously participate in the interactive teaching activities, stimulating the learners' motivation at the same time; secondly, the learners clearly knows the learning content and learning degree, and actively participates in the interactive activities of teaching.

2.1 Teaching objectives

To set up teaching objectives is the first step of the ecological English teaching model. The teaching aim of college English is to cultivate students' English comprehensive ability in language use, especially listening and speaking skills. In order to make them communicate effectively in English in their future work and social activities both in written and spoken language, their autonomous learning abilities and comprehensive cultural literacy should be also improved to meet the requirements of the economic development in our country and international communication in the world[7]. From the perspective of ecolinguistics, English teaching no longer aims at learning language knowledge, but at cultivating students' comprehensive abilities with "multiple goals", namely, language skills training, language knowledge broadening, emotional attitude cultivating, learning strategies exploring, cultural awareness training, and cultural literacy improving. Therefore, teachers should guide students to acquire appropriate learning methods, establish harmonious interpersonal relationship, cultivate critical thinking ability, establish cross-cultural communication consciousness and improve cross-cultural communication ability in language teaching activities. In intercultural communication, teachers should help students to express their thoughts in a authentic way while respecting the differences between Chinese and Western cultures and two different thinking ways. On the other hand, we should put an end to culture hegemony while broadening students' international vision, which means that when accepting western culture, we should also pay attention to the spreading of Chinese culture.

2.2 Teaching content

The core of English teaching has always been English language knowledge. Therefore, from the perspective of ecological linguistics, the teaching content should not only include language knowledge such as pronunciation, vocabulary and grammar in a narrow sense, but also include cultural knowledge such as history, geography and literature of different cultures. The teaching materials should not only include the formal written language of knowledge and literature, but also the informal oral language of daily communication, which provides students with more colorful learning materials. Though textbook is a carrier of teaching content, it goes far beyond a textbook. Otherwise, the teaching content should not only provides students with materials for language knowledge and language skills training, but also combine language knowledge, language skills, students' emotions and attitudes, learning strategies and cross-cultural communication ability training, so as to develop students' all-round talents in the new era. When selecting English language content, we should pay attention to the comparison of Chinese culture and western culture. English language learning not only provides an opportunity for students to learn the society, culture and customs of English-speaking countries, or enhance their understanding of western cultures and values, but also to spread China's brilliant traditional cultures through the language medium. When promoting cultural exchanges between China and Western countries, China's national soft power will be enhanced. However, for a long time, our English textbooks rarely mention about Chinese humanity landscapes and traditional Chinese cultures, so that our students can hardly convey Chinese culture in cross-cultural communications effectively. There also exits a big gap in cultural communication that the input of western culture is greater than the output of Chinese culture. Therefore, teachers should compare Chinese and Western cultures properly in classroom teaching and guide students to pay more attention to Chinese culture, which can not only make students get closer to the language knowledge, but also stimulate students' interest in English learning, only in this way that English can truly become a bridge of cross-cultural communication.

2.3 Teaching methods

The content of teaching materials from the perspective of ecolinguistics can be diversified. Therefore, the teaching method should be flexible and variable according to the content, adhering to the concept of “teaching students according to their aptitude”. Various teaching methods can be adopted in specific teaching, such as traditional grammar translation method, demonstration method, immersive situational teaching method, task-based teaching method, ecological language teaching method and so on.

2.3.1 Teaching language knowledge

Classroom teaching method is the teacher-centered one-way information transmission, which is the most effective method to impart language knowledge, and is suitable for the actual situation of large English class teaching in China. Classroom teaching method, mainly represented by grammar translation method, has certain advantages in college English learning. It requires students to have a certain degree of language knowledge foundation, which is more suitable for college students. When using this teaching method, the requirement for teacher to organize the class is relatively lower, and the teaching effect can be mostly satisfied in class with large class size. However, the disadvantage of this teaching method is that students can not actively participate in the classroom teaching, making the teaching process to be depressing and boring. Therefore, teachers should supplement some extra-curricular knowledge to arouse and stimulate students’ interest in learning, and take effective measures to help students to digest the language knowledge they learned.

2.3.2 Cultural knowledge acquisition

An active classroom atmosphere should be created by the teacher to guide students to the language learning and cultural acquisition context as follows: first, a harmonious learning atmosphere is a prerequisite for cultural immersion. Students will try to express themselves in English classroom actively and boldly in a harmonious and relaxed learning atmosphere filled with cultural elements; secondly, in a harmonious teaching atmosphere, teaching objectives can achieved by creating specific cultural scenes, so that classroom teaching can become the exhibition center of westerners’ life and customs or local customs. In a given social and cultural atmosphere, students will use cultural and language knowledge to perform role plays, actively participate in teaching activities, experience and absorb western culture knowledge. Moreover, teachers should enrich the cultural knowledge in classroom teaching that is always glossed over in most textbooks. While making full use of teaching materials, teachers can depend more on modern multimedia teaching technology. For example, learning materials can include pictures, audio, video and other multimedia materials to add more comparison of Chinese and western culture.

2.3.3 Thinking development training

The most effective way to train thinking development is the task-based teaching method, which means to formulate specific learning tasks. Ecological language teaching requires teachers to develop students' critical thinking ability while learning language, so that students can be competitive as part of the ecological international environment and get fit for the coming job and living conditions. When designing questions, teachers should take the individual student's psychological ecology environment into consideration to arouse their interest in learning and improve their thinking ability. Students' current learning and living experience will be most likely to have an impact on their future language structure. They will have their own language knowledge structure evolved according to their possessed living and learning experience.

2.4 Ecological learning evaluation system

Based on the concept that language is an ecosystem, ecolinguists believe that the evaluation system should cover various elements in the system, including teachers, learners, language and its culture environment. The purpose of this multiple evaluation system is to make teachers reflect on the rationality and pertinence of teaching design, and make students reflect on their language and culture learning initiative and effect. As for school's administrative departments, they should ensure a healthy language and culture learning environment, and provide reference points to test students' development degree instead of traditional evaluation indexes. From the perspective of ecological linguistics, learning evaluation not only focus on students' academic performance, such as the English language and culture knowledge, but also students' potential development abilities. In addition, students' self-adjustment ability in specific English cultural context and intercultural communication abilities should also be evaluated in the evaluation system.

The traditional way to form final reports about students cannot fully reflect their language abilities, which do not pay attention to students' personality development during the learning process and will not be very helpful for teachers to make some improvement in their teaching in the future. Another important purpose for evaluation is to promote teachers' professional quality in the development of the evaluation system. In ecological language teaching, teachers' language knowledge and cultural accomplishment play a very important role for the sustainability and stability of the leaching ecosystem development. They should do reflection on their teaching constantly and expand their knowledge of both language and culture according to the evaluation results relating to students' language knowledge and culture. The multi-evaluation results are of great importance to students, teachers and educational administrative departments.

As for students, the evaluation results reflect clearly on their learning deficiencies in knowledge and provide valuable feedback information for their future study. As for teachers, the evaluation results can make them know the students' language proficiency and how well the teaching objectives have been completed, which provides valuable reference information for later teaching design and teaching implementation. For the administrative department of education, the teaching evaluation results not only enable us to understand students' comprehensive ability of language, but also provide an evidence for macro-adjustment of language teaching policies and regulations. In a word, ecological language teaching evaluation is a dynamic process from evaluation to feedback and reevaluation. The essence of evaluation is to promote the long-term development of both teachers and students. The evaluation form may include the students' file record, their activity performance, the regular tests and their language proficiency test results, combining the formative evaluation and the final evaluation to increase their learning motivations in comprehensive abilities development.

3 Conclusion

Ecolinguistics considers the ecological environment of language comprehensively and regards English teaching as a dynamic ecosystem. In this system, teachers and students are the subjects of activities, English language as the carrier, and Chinese and western social culture as the living environment. All elements in the system are interrelated. The sustainable development of the system needs appropriate ecological environment, namely classroom environment, campus cultural atmosphere, social cultural atmosphere, policies and regulations, etc. In addition, teachers and students need to give full play to their active initiatives.Teachers should guide students to choose their learning content and learning methods independently, help them to solve learning problems independently and regulate their learning process. Students should participate in language teaching activities actively rather than receive knowledge from teachers passively. Only in such a dynamic system can students put what they have learned into practice and improve their intercultural communication ability.

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Pedagogical Challenges in Online Learning: 'Maxiagogy' as a Transformative Panacea Owing to the COVID-19 Outbreak

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Abstract

Purpose – The COVID-19 pandemic has forced all sectors, including education sectors, to make impulsive adjustments. In the implementation, educational institutions at all levels have undergone rapid changes as they had to adopt online learning. This study investigates the underlying factors that raise questions and complaints from stakeholders due to the changes in delivery from the face-to-face mode to online learning.

Design/methodology/approach – The critical factor identified as a cause of the social confusion is a pedagogical issue. The pedagogical crisis presumably occurred due to the sudden changes from face-to-face teaching to the online learning mode. To untangle these tangled threads, this study collected data from various sources in an effort to understand the importance of the pedagogical issue in online learning. This issue needs to be investigated from diverse perspectives, ranging from: (1) the contexts that drive the acceleration of the use of online learning; (2) the evolution of the online learning generation; (3) open education, online learning, and the conception of higher education; (4) the system of online learning; and (5) the evolution of pedagogy in online learning. Methodologically, the approach is a descriptive-qualitative one through some literature review activities and a series of focus group discussions on the critical analysis. The data collected are entirely secondary data in the form of content analysis. The sources were: (a) journals; (b) reports; (c) search engines; (d) websites containing scientific articles; (e) research papers; and (f) unpublished academic papers.

Findings – This study succeeded in proposing a breakthrough alternative pedagogy that needs to be criticized as a transformative pedagogy, i.e. 'maxiagogy' based on communalism. We were familiar with pedagogy, andragogy, and heutagogy (including peeralogy and cybergogy) and cognitive-behaviourism, constructivism, and connectivism. This study finally confirmed 'maxiagogy' as the (new) transformative pedagogy (communalism-based) with its drawbacks and strengths. This is in line with the spirit of online learning for the 21st century — that is, learning is exciting, enjoyable, accessible, easy to find, reliable, and flexible.

Originality/value/implications – The rise of the new transformative pedagogy will not solve the real pedagogical crisis in online learning. However, this study shows that 'communalism-based maxiagogy' can be used as a transformative pedagogy with respect to the pressures of the 21st century and the demands of millennial learners, regardless of whether the Covid-19 crisis occurred or not. 'Maxiagogy' ultimately places learners at the centre of learning, with two fundamental beliefs — flexibility and trust — becoming self-directed and self-determined learners.

Keywords: Pedagogy, online learning, COVID-19 pandemic, connectivism, transformative pedagogy, self-determined learning.

1 Introduction

The sudden outbreak of the COVID-19 pandemic that hit all parts of the world has forced all sectors of life to make changes and adjustments. This coercive situation also concerns the education sectors and related stakeholders. Online learning, which has been available so far, is the only option because face-to-face learning is no longer feasible. This sudden change, of course, caused confusion which also suddenly comes. The unpreparedness of stakeholders to accept change, as a sudden blow, causes social chaos in the community (Dhawan, 2020). It is not only students and parents who face the confusion but also teachers, school management, and even education officials at all levels. They experience an atmosphere of panic with a high level of complexity.

Apart from the fear of being exposed to the COVID-19, which is very dangerous with a very high transmission rate, it raises various questions and complaints related to the implementation of education previously through face-to-face learning switching to online learning. Concerns have begun to arise, considering that it cannot be estimated when the pandemic will end.

Simultaneously, the implementation of face-to-face to online learning as it is carried out in a hurry can cause problems in learning outcomes, as partly emphasized by Nartiningrum and Nugroho (2020). Some experts even predict that if this crisis is not guardedly anticipated and handled, it will result in generation loss or educational stunting during this pandemic crisis, especially in the Indonesian context.

Many aspects must be investigated then to avoid this generation lost issues. From the initial observations, studies on the importance of the availability of technological infrastructure, the availability of qualified educators, the completeness of learning resources, financial supports, and administrative aspects have been widely studied. These implied that this study aims to ensure that the provision of online learning can safely replace face-to-face learning with the same quality of inputs, processes, outputs, outcomes, and impacts, as also highlighted by Supriyatno and Kurniawan (2020).

However, paying attention to the news during 2020 up to April 2021, especially the state of learning during the pandemic period in Indonesia, the implication of conducting online learning still raises mainly various structural concerns. We are now even familiarized with educational stunting issues in addition to the lost generation issues. Based on the analysis of existing conditions, what seems less touched, is the pedagogical aspects in online learning, as partly supported by Rapanta et al. (2020). There is suspicion that the learning processes carried out during this pandemic crisis were not cautiously considering that pedagogical aspect. It can be said then that the implementation of online learning is factually such a kind of 'zooming-in' the face-to-face class room activities using ICT without paying attention to the pedagogical aspect at all.

In plain view, things previously described are common and appear in classes at almost all levels of education. This study, therefore, aims to investigate the extent to which pedagogical elements have been included in the online learning system that has been, is being, and will be implemented so far. At the same time, this study aims to find a breakthrough transformative pedagogy as an alternative so that online learning can be avoided as a cause of lost generation and/or educational stunting problems, again, especially in the Indonesian context.

2 Previous and Current Related Studies

Conceptually, this study considers some basic notions that will eventually be linked to pedagogical aspects, particularly pedagogy in online learning. This study finds (as inspiration and needs to be elaborated further) the need to alertly include pedagogy in online learning. This is used as an analytical tool to initiate transformative pedagogy which suitable for online learning. This is crucial given the rush to implement online learning due to the COVID-19 pandemic crisis. The following elaborative description is a structured study that underlies the intended transformative pedagogy as an alternative to anticipate and deal with various pedagogical challenges.

First. On the online learning (r)evolution. As an inspiration, the study refers to the idea of and then modified from both Taylor (2001) and McTee (2010) as presented in Figure 1 and summarized in Table 1.

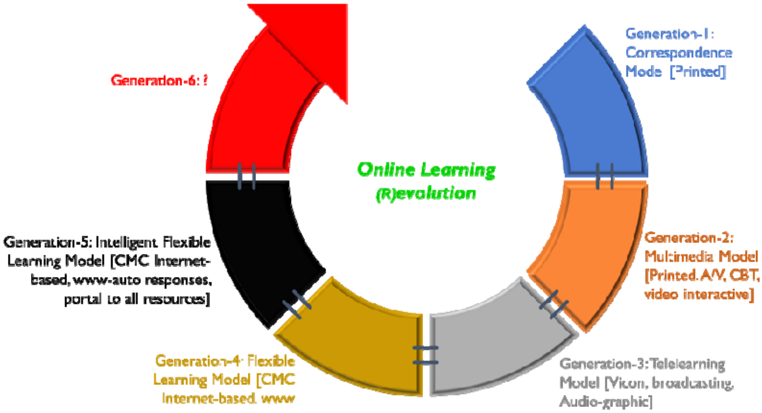

Figure 1. Online Learning (R)evolution

Table 1. Traits an Online Learning and Associated Technology

Models of DE and Associated Delivery Technology	Characteristics of Delivery Technology					Institutional Variables Cost → 0
	FLEXIBILITY			Highly Refine Materials	Advance Interactive Delivery	
	TIME	PLACE	PACE			
1. Interactive multimedia Delivery	Yes	Yes	Yes	Yes	Yes	Yes
2. Internet-based access to www resources	Yes	Yes	Yes	Yes	Yes	Yes
3. CMC – Using automated response systems	Yes	Yes	Yes	Yes	Yes	Yes
4. Campus portal access to institutional processes-resources	Yes	Yes	Yes	Yes	Yes	Yes

1. Key features

Vicon, audio-graphics, www & Internet www – resource sharing asynchronous-live communication, integration of media and technology for multiple platforms. learner and teacher options for the rise of web 2 technologies

2. Pedagogy

Behaviorism, cognitivism, contructivism, social constructivism

3. Content owner

Universities and global community

4. Curriculum

As more knowledge producers enter the market (formal, informaland self-publishing) the curricula increasingly become open and fluid. OER, YouTube and other social technologies are changing the nature of knowledge, the curriculum and the validation of knowledge

5. Interaction

Content starting to move away from the university – asynchronous and synchronous interaction – mass delivery becomes problematic and demands for interaction challenge ICTs

6. Medium

Text, images, sound and video

7. Production

Printing press, sound and video, film recording and computer design, programming, user involvement

8. Storage

Digital storage media (CD, DVD, memory sticks, central servers, HD)

9. Delivery

Mail system, TV, tel, computers, video and sound playback starting to become a generic device and Internet/www as a generic platform

Second. On open education, online learning, and conceptions of higher education. The study refers to Belawati (2019), as shown in Figure 2.

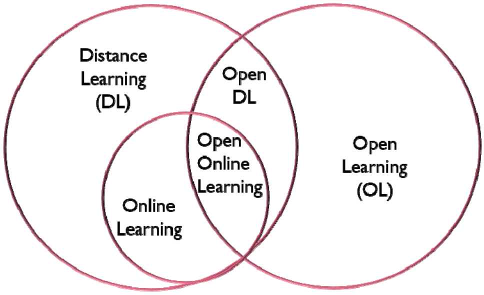

Figure 2. Distance Learning, Online Learning Open Learning

Correspondingly, at a theoretical level, the basic concept of higher education has four main characteristics (Barnett, 1992). The first form is higher education as a resource or teaching university, which functions to produce highly qualified human resources. The second form is higher education as a research university. The third form is higher education as an efficient management university. The fourth is higher education as a university for life enrichment. Another form of higher education, introduced by Clark (2001), is entrepreneurial university. Each form of those universities has specific and unique characteristics to influence the choice of learning pedagogy to be applied, especially in an online learning mode of delivery.

Third. On educational and online learning systems. Regarding this concept, the study refers to the ideas formulated by Sembiring (2020a) and Sembiring (2020b), which are simplified as illustrated in Figure 3.

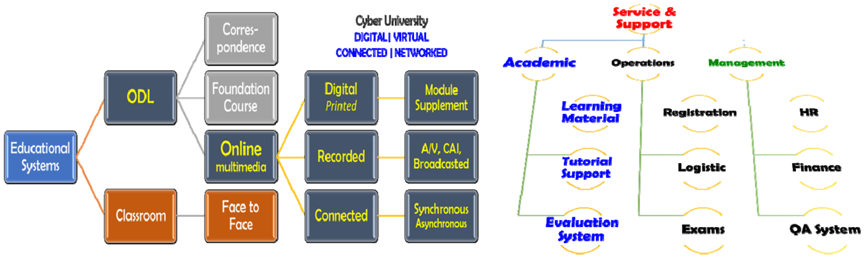

Figure 3. The Educational and Online Learning Systems

Fourth. On the evolution. At this stage, the study refers to Anderson and Dron (2011), as summarized in Table 2. Besides, Siemens (2005) elaboratively contended that learning is a complete knowledge that can be acted upon, which originated and may have sources outside of oneself.

Moreover, according to Belawati (2019), knowledge resulted from interactions in various network nodes. This implied that learning is a self-development activity. This description leads to the term called distributed learning. Students become partners who create knowledge with the teacher. This means greater flexibility in the curriculum, more considerable autonomy for learners, and more effective use of technology where learning took place.

Table 2. Three Generations of Distance Education Pedagogy

Gen. of DE Pedagogy	*Technology*	*Learning activities*	*Learner granularity*	*Content granularity*	*Evaluation*	*Teacher role*	*Scalability*
Cognitive–behaviourism	Mass media: Print, TV, radio, one-to-one comm	Read and watch	Individual	Fine: scripted and designed from the ground up	Recall	Content creator, sage on the stage	High
Constructivism	Conferencing (A/V and Web), many-to-many communication	Discuss, create, construct	Group	Medium: scaffolded and arranged, teacher-guided	Synthesize: essays	Discussion leader, guide on the side	Low
Connectivism	Web 2.0: Socnet, aggregation & recommender systems	Explore, connect, create, and evaluate	Network	Coarse: mainly at object and person level, self-created	Artifact creation	Critical friend, co-traveler	Medium

Fifth. On learning experience and learning focus. Here, the study mainly refers to Garrison (2009) about the community of inquiry in online learning. The three main elements of the learning experience: cognitive presence, teaching presence, and social presence. Cormier (2008) previously included community as a curriculum. This implies that environmental elements are included as a part of the learning experience. In other words, Sembiring (2008) and Anderson (2017) mention the importance of student presence in making learning experiences comprehensive and integrated (as part of environmental presence). The summary of these notions is comprehensively illustrated in Figure 4.

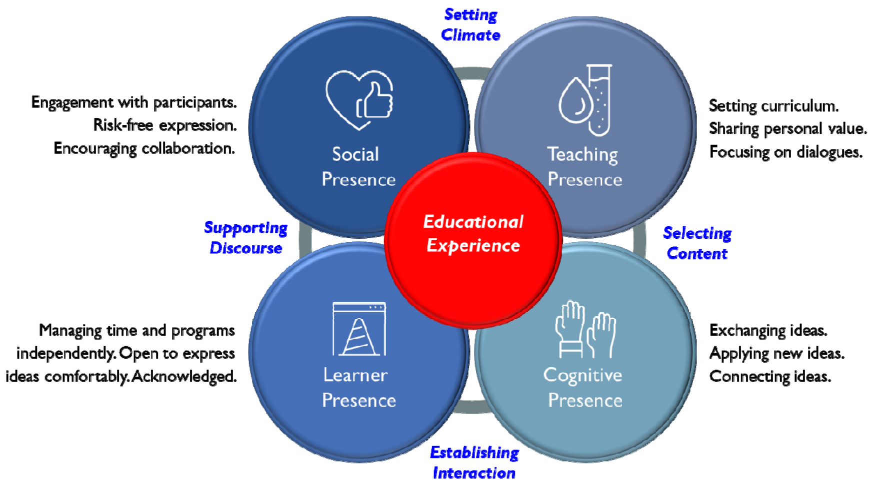

Figure 4. The Four Main Elements of Learning Experience

3 The Context and Research Design

In this study, we use several definitions, starting with the origin of the word education. Education is extracted from two Latin words, i.e., *educare* and *educere*, which means to form and lead, respectively (Bass & Good, 2004). Furthermore, we define pedagogy as an educational activity based on educational theory. Andragogy is the process of involving adult learners in a structured learning experience. Heutagogy is an educational activity that puts students in full responsibility for what and when they must learn, as in a learning framework, and then it puts adults responsible for their progress (Heick, 2015).

Methodically, this study utilizes a descriptive-qualitative approach, following Creswell (2015). That is contextually to comprehend the importance of online learning in a crisis period due to a pandemic outbreak. This outbreak forces learning mode to shift from face-to-face to online learning. Apart from carrying capacity to facilitate learning, including adequate communication and information technology aspects, it turns out that other critical and potential issues go unnoticed. The problem is related to the pedagogical issue that is adequate for online learning. And, not to cause obstacles in the implementation stage. Pedagogical issues related to online learning that pose challenges, which may become new crises, need to be cautiously identified and considered.

For this reason, it is necessary to carry out an investigation and assess through the identification process with respect to previous and current related studies. It is essential to collect data (information) to describe latent pedagogical problems that can become obstacles in implementing online learning, which is detrimental to many parties, mainly to most students. The research tool used to analyze data (information) collected from various sources in this research is in content analysis form (descriptive-qualitative approach) under structured literature review activities and focus group discussions series with experts by following Mishra (2016).

This study obtained material in the conceptual and operational thoughts as a qualitative consideration and is entirely based on secondary data. The collection and systematic review process are carried out for each literature collected. Secondary data sources used were obtained from: (1) journals, (2) reports, (3) engine searches, (4) websites containing scientific articles, (5) research papers, and including some (6) unpublished scientific pieces of work.

The results of collecting, analyzing, and summarizing data/information are used as the basis for proposing the breakthrough ideas. The idea of a breakthrough is expected to be a transformative resolution to offer 'new pedagogy' in online learning. This transformative idea is also in accordance with the skills for 21st-century skills, regardless of a COVID-19 pandemic is present or not. This idea then needs to be scientifically tested to find out its reliability.

4 The Breakthrough Ideas and Discussions

Having summarized information obtained and intensely discussed in focus group discussions series as described in the previous section, this study conclusively considers the presence of learners (including their environment) as a gap that must be addressed and amended associated with online learning. In face-to-face interaction, this gap (students' presence) is not quite disturbed from a pedagogical perspective. Therefore, the essential design community of inquiry by Tucker (2019), illustrated in Table 3 (refer to the last row), needs to add **one new** element, i.e., learners' presence.

Table 3. The New Community of Inquiry

The New Community of Inquiry Plus	
Social Presence	*What? The ability to assert one's belief, feeling, and personality to establish relationship, trust and open communication on and offline* *How? Build community with activities and icebreakers, encourage respectful discussions on and offline, and give learners time to work collaboratively on shared tasks*
Cognitive Presence	*What? The ability to construct meaning through a combination of individual experience and reflection the social negotiation and collaborative constructivism* *How? Teach students how to work through practical inquiry model – triggering event, exploration, integration and resolution*
Teaching Presence	*What? The ability to design, facilitate and direct the social and cognitive presence to achieve high quality learning outcomes for students* *How? Design on and offline learning to engage students to collaborative constructivism. Facilitate relationship building and provide individualized support. Guide the learning happening on and offline*
Learner Presence	*What? The ability and freedom to decide what to learn and when to learn it with others by applying any kind of available learning resources and tools.* *How? Equip the self with the necessary information related to the field to be studied to support career and self-esteem*

This study dares to describe what and how 'maxiagogy' is harmonized with what had been stated by experts. What is truly meant by communalism-based 'maxiagogy'? 'Maxiagogy' is an approach that gives students the ability and freedom to decide what to and when to learn it with or without other supports using kinds of available and appropriate learning resources and tools. Then, how can 'maxiagogy' be practically and successfully implemented? 'Maxiagogy' equips students with various information related to the field of study they take to support their career and life towards self-esteem based on self-determined learning.

How to ensure, or what guarantees, that 'maxiagogy' will be compatible with online learning systems? Maxiagogy must be designed, recognized, and accomplished by following the inspiration introduced by Santaniello (2017), illustrated in Figure 5.

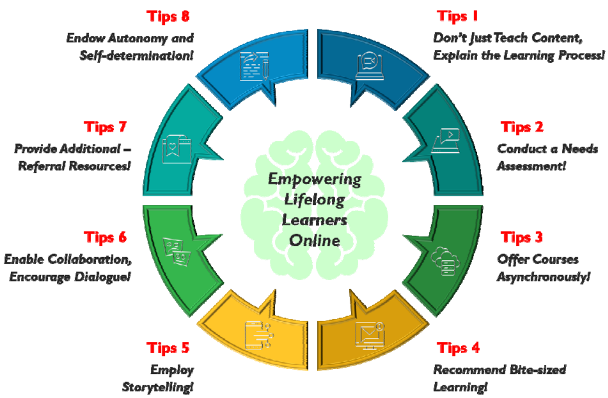

Figure 5. Tips to Empower Lifelong Learners Online

Those eight tips (Figure 5) are ways of guaranteeing to empower students to become lifelong learners in online learning. This is based on the belief that whoever teaches in learning, he is learning! Correspondingly, anyone who learns in learning mode is also actually learning!

What should then be considered and how to design pedagogy in online learning? Inspired by Stommel (2020), developing pedagogy for online learning – now referred to as 'communalism-based maxiagogy' – can be ensured by inclusively included two main keywords: flexibility and trust!

Again, the main principles in any pedagogy, especially in emergencies like this pandemic crisis, are flexibility and trust. On this basis, designing online learning that has considered the elements of pedagogy in an integrated manner includes several critical features, as illustrated in Figure 6.

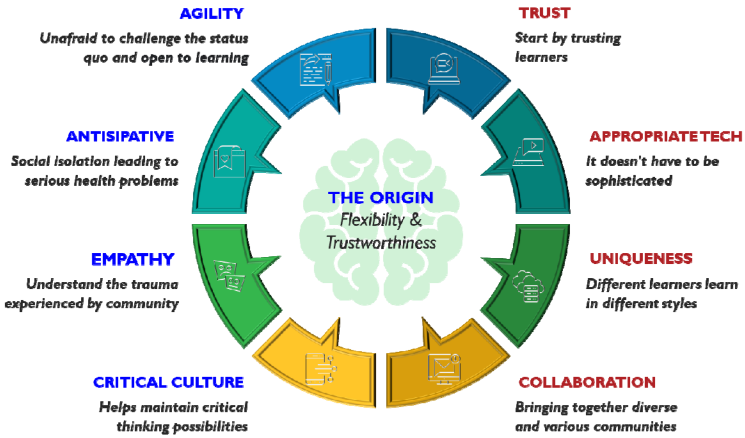

Figure 6. Inclusive Pedagogies for Online Learning

At this stage, we can link and integrate comprehensively in an evolutionary manner, starting from pedagogy, andragogy, heutagogy, and 'maxiagogy.'. The evolutionary "gogy" series, as presented in Table 4, is linked to dependencies, learning resources, learning reasons (and focus), motivation, and the role of the educator.

At this stage, under 'maxiagogy' as a transformative pedagogy for online learning, students become fully autonomous (self-directed learning leads to the self-determined learner). With features that align with the demands of 21st-century learning and the coercion of the COVID-19 pandemic outbreak, 'maxiagogy' is just right to be considered an alternative to the 'new pedagogy' online learning.

Now let us cautiously notice the traits of 'maxiagogy' as illustrated in Table 4. Let us concentrate on the last column of Table 4. Under the six main characteristics, we are convinced that the center of learning under 'maxiagogy' is the student. This fact will undoubtedly lead to providing the opportunity to the student to be a fully autonomous learner. The 21st century calls for the 21st skills. The traits of the 21st learners tend to put the universe as a resource of learning. That is why the basis of this new 'gogy' is referred to as the so-called 'communalism-based.'

Table 4. Evolution of Pedagogy, Andragogy, Heutagogy, and 'Maxiagogy'

	Pedagogy Children Learning	*Andragogy* Adults Learning	*Heutagogy* Self-Directed Learning	*Maxiagogy* Fully-Autonomous Learning
Dependence	Learner is dependent. Teacher determines on what, how and when to learn.	Adults are independent. They strive for autonomy and self-direction in learning	Learners are interdependent. They identify the potential to learn from novel experiences and manage their own learning	*Extremely autonomous*
Resource of Learning	Learner has few resources. Teacher devises transmission to store knowledge to learner's head	Adults use their own experiences and other's experiences	Teacher provides some resources but the learner decides the path by negotiating the learning	*The Universe (Communities)*
Reasons for Learning	Learn to advance to the next level	Adult learns when they experience a need to know or to perform more effectively	Learning is not necessarily linear and , planned, but on the potential to learn in the novel situation	*Humans who benefit the universe without limits*
Focus of Learning	Learning is subject centred, focused in prescribed curriculum and planned sequences according to the logic of subject matter	Adult learning is a task or problem oriented	Learner can go beyond problem solving by enabling pro-activity using their experiences (reflection, interaction with others)	*That is fun and needed by the development*
Motivation	Motivation come from external sources	Motivation stems from internal sources. The increased self-esteem and recognition come from performance	Self-efficacy and knowing how to learn, creativity, ability to use this qualities in novel and familiar situation and working with others	*Self-esteem Self-determined*
Role of the Teachers	Designs the learning process, imposes materials, is assumed to know best	Enabler or facilitator, climate of collaboration, respect and openness	Develop learner's capability (How to learn, high self-efficacy, work with others)	*Almost wiped out*

5 Closing Notes and Follow-Up

From the previous description, in accordance with the objectives of this study, it can be mapped that there could be pedagogical problems in online learning. Pedagogical issues in learning are caused by the haste in online learning on the one hand and a shift of learning orientation on the other hands. Therefore, this study has convincingly proposed transformative pedagogy as an alternative to deal with the pedagogical crisis in implementing online learning due to a pandemic outbreak. Chronologically, the evolution of those "gogy" in online learning is illustrated in Figure 7.

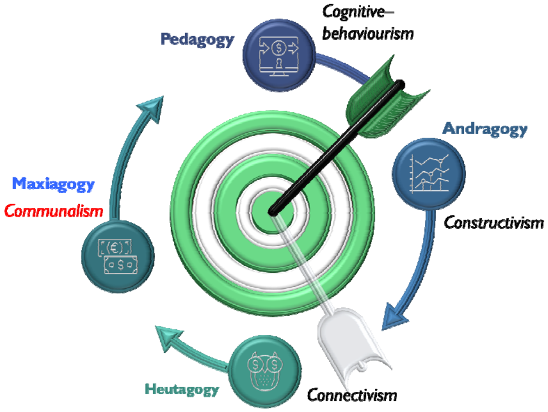

Figure 7. Evolution of Pedagogy from Time to Time

Figure 7 exhibits that 'maxiagogy' will become a 'new' pedagogy appropriate for online learning. Additionally, it is in accordance with the 21st-century learning milieu. Conclusively, 'maxiagogy' is defined as a transformative and alternative learning approach that utilizes elements of art, science, and skills in managing learning processes using scattered and connected resources with the help of appropriate technology to prepare functionally and sustainably smart, character, and independent human being in the digital era.

The goal of implementing 'communalism-based maxiagogy' is to realize learning, especially in online learning, so that it is contextual, situational, and functional. With this kind of approach, learning that motivates and inspire students can be realized even through online learning. The essence of applying 'communalism-based maxiagogy' is to impress students to be more curious, feel at home, be addicted, and finally fell in love with learning, as partially emphasized by Kesler (2019). Conceptually and operationally, the characteristics of online learning must be exhaustively framed and making learning exciting and enjoyable from students' perspectives. Apart from being accessible, online learning must be easy to find and reliable as well as flexible.

Reflection for future consideration! How to make these demands take place? Let us grasp the following five approaches (Lynch, 2019): (1) challenge ourselves, (2) change the classroom dynamic, (3) present alternative views, (4) change our assessments scheme, and (5) encourage activism.

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Confidence in Implementing Project-based Learning in STEM Education: Perspectives of Hong Kong In-service Teachers

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Abstract
Purpose – In response to the advance of technology and its impact on society, STEM education has been advocated in this decade. Teachers are highly encouraged to apply a project-based learning approach to promote STEM education. However, due to the cross-disciplinary nature of STEM education, nurturing students in STEM education using this learning approach is a challenging task. This study aimed to explore whether in-service teachers are confident in applying a project-based learning approach in STEM education.
Design/methodology/approach – This study adopted the survey research method to collect opinions from the participants. Thirty-seven in-service teachers of primary and secondary schools in Hong Kong who attended STEM pedagogical workshops delivered by the researcher were invited to fill out an online questionnaire.
Findings – All participants in this study, both primary and secondary school teachers, said that they are not very confident in applying a project-based learning approach to nurture students in STEM education.
Originality/value/implications – The success of STEM education, to a great extent, depends on teaching effectiveness. This study reveals that although teachers are highly encouraged to apply a project-based learning approach to engage students in learning STEM, they are not confident enough in using this pedagogical method in STEM education. This suggests that more professional training in project-based learning in STEM education for teachers is required.

Keywords: STEM education, teacher education, project-based learning, teaching confidence, self-efficacy

1 Introduction

The rapid development of science and technology in this contemporary era has led to an immense impact on the educational trend. Particularly, integrated science, technology, engineering, and mathematics (STEM) education has been highly advocated in this couple of decades to cater for students' learning needs (Gao et al., 2020; Li et al., 2020). In response to this initiative, different countries around the world have initiated policies to promote integrated STEM education (Ng, 2017). The main underlying reasons are the economic benefits brought by integrated STEM education to individuals and society. Evidence has shown that students who equip with STEM-related knowledge and skills are usually able to obtain a higher income and better job security. The economics of a country can also grow sustainably with the continuous supply of human resources in STEM domains (Saxton et al., 2014).

A universally agreed definition of integrated STEM education has not been developed. Kelley and Knowles (2016) suggested that integrated STEM education is "the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning" (p. 3). This definition clearly highlights the interdisciplinary nature of integrated STEM education and the practices in our real-life situation. Students are encouraged to learn in an interconnecting approach.

In response to the educational trend, the Education Bureau of Hong Kong published a report on the promotion of STEM education in 2016. This report highlighted the demand to renew the curricula of related areas to enrich student's learning. It aims to nurture versatile talents to meet the challenges in the 21st century. However, although integrated STEM education may bring many benefits to students, its implementation is not a straightforward issue. The success of STEM education, to a great extent, depends on teacher's confidence and competence. Research has suggested that student achievement in STEM areas positively correlates to the quality of teaching (McDonald, 2016). Therefore, to achieve the overall goal, a critical factor is teachers' confidence and expertise in designing and implementing STEM-related learning activities.

2 Teachers and Teaching in Integrated STEM Education

To implement STEM education, teachers usually apply various pedagogies to organize STEM-related learning activities in a classroom. For example in the study by Smith et al. (2015), the teaching methods used in STEM lessons include lecture, demonstration, discussion, cooperative learning, experiment and role-playing. To engage students in STEM learning beyond classrooms, a commonly used pedagogy is the project-based learning approach (see, for example, Lin et al., 2021). It is a systematic teaching and learning method to engages students in meaning authentic tasks. Capraro et al. (2013) defined STEM project-based learning as an "ill-defined task within a well-defined outcome situated with a contextually rich task requiring students to solve several problems which when considered in their entirety showcase student mastery of several concepts of various STEM subjects" (p. 15). Using this approach to learn, students are expected to acquire knowledge and develop generic skills such as problem-solving, decision-making and creative abilities in the process by developing a product or presentation. Project-based learning can be implemented individually or on a group basis to promote collaborative learning (Hwang et al, 2020). Compared with the traditional teacher-led lessons, project-based learning is able to bring a greater positive effect on students' academic achievement (Chen & Yang, 2019).

However, implementing STEM project-based learning is a challenging task. If teachers attempt to engage students in STEM project-based learning, they need to consider the difficulty and complexity of the project. The tasks embedded in the project should be meaningful, challenging but not too tough. Only the project with a reasonable level of difficulty, students are able to apply the knowledge they have learned to carry out the project (Hwang et al., 2020). More importantly, the project should involve real-life problems that required knowledge and skills in multiple disciplines so that students can learn and apply integrated knowledge. While teachers hold positive views on STEM education, research (McDonald, 2016) suggested that they consistently expressed difficulties in instructing students in STEM education. According to the comprehensive review conducted by Margot and Kettler (2019), the studies by Ng and Cheng (2019), and Shernoff et al. (2017), teachers consistently expressed their difficulties on the lack of content knowledge across multiple STEM disciplines. The teachers often taught the four STEM disciplines in a disjointed manner without much integration. They also raised the challenge of exploiting effective pedagogies for STEM education. In the study by Han et al. (2015), the teachers could not effectively instruct students' STEM projects, even though they received relevant professional training. In another study by Smith et al. (2015), teachers reported that they lacked the confidence to arrange STEM-related learning activities such as designing an experiment. It inevitably reduces the effectiveness of promoting STEM education. Therefore, teacher's confidence to apply effective pedagogy, such as a project-based learning approach, to promote STEM education is critical for the success of STEM education.

Although the Education Bureau (2016) in Hong Kong strongly encouraged teachers to apply a project-based learning approach for students to learning knowledge and skills in multiple disciplines in STEM, teachers may not be confident enough in implementing STEM project-based learning. Research has evidenced that confidence in completing certain tasks has a positive correlation with subsequence performance (see, for example, Lee, 2018; Zarza-Alzugaray et al., 2020). If teachers do not have a high level of confidence to apply project-based learning in an integrated STEM subject, they will unlikely have good teaching effectiveness to promote STEM education. This study, therefore, aimed to explore in-service teachers' confidence level to apply project-based learning in STEM education. The research question is as follow.

"What is the confidence level of in-service teachers in Hong Kong to apply a project-based learning approach to promote STEM education?"

3 Methods

To obtain the opinions from the participants, this study adopted the survey research method. Thirty-seven in-service teachers of primary and secondary schools in Hong Kong who attended STEM pedagogical workshops delivered by the researcher were invited to fill out an online questionnaire. The participants have informed the purpose of the questionnaire and their participation is voluntary. The participants included 13 females and 24 males. The level of teaching of the participants is shown in Table 1.

Table 1. Level of teaching of the participants.

Teaching level	Frequency	Percent
Primary Junior	1	2.7
Primary Junior & Senior	6	16.2
Primary Senior	5	13.5
Secondary Junior	13	35.1
Secondary Senior	12	32.4
Total	37	100

The questionnaire was adapted from the study by Hodges et al. (2016). The questions are listed below.

Q1. I am confident to help my students formulate research questions and investigations when beginning a new, real-world challenge.

Q2. I am confident to help my students identify and address their misconceptions through exploration and reflection.

Q3. I am confident to help my students identify patterns or trends in data from investigations and research they conduct.

Q4. I am confident to help my students identify and extract critical information from a given challenge, scenario, or observation of phenomena.

Q5. I am confident to help my students connect what they have learned to real-world situations.

Q6. I am confident to help my students connect evidence they gather during an investigation to the claims they make.

Q7. I am confident to let my students struggle with concepts and activities during the learning process, where I refrain from providing immediate answers or solutions.

Q8. I am confident to help my students use different methods to solve problems.

Q9. I am confident to help my students conduct group investigations with the goal of revealing concepts.

Q10. I am confident to help my students use claims, evidence, and reasoning to discuss concepts.

Q11. I am confident to help students use the scientific content they learn when supporting their claims.

Q12. I am confident to help my students connect knowledge of their previous investigations, giving scientific meaning to the investigations.

Q13. I am confident to help my students connect knowledge in different areas.

Q14. I am confident to help my students present the results of their investigations to the class with posters or other media.

As stated by Hodges et al. (2016), the questionnaire comprises seven pairs of questions to examine teacher's confidence in different dimensions to instruct students' STEM project. Q1 and Q4 of the questionnaire ask about teacher's confidence to help students organize the challenge in the inquiry. Q8 and Q9 address teacher's confidence to engage students in the inquiry learning process. Q3 and Q10 examine teacher's confidence to help students explore the knowledge embedded in the inquiry. Q6 and Q11 look at teacher's confidence to help students reflect on what they have learnt and connect it to the inquiry. Q7 and Q12 investigate teacher's confidence to help students derive explanations of their claims. Q2 and Q13 review teacher's confidence to help students develop a scientific understanding of the inquiry. Q5 and Q14 evaluate teacher's confidence to help students share the results of the inquiry.

The teachers were asked to respond to the above questions to express their confidence level of instructing a student project in an integrated STEM subject. For each question, they were invited to express the level of confidence on a 7-point Likert scale, with 1 indicates not confident and 7 indicates very confident.

4 Results

The descriptive statistics of Q1-Q14 are shown in Table 2. Regarding the confidence of implementing project-based learning in an integrated STEM subject, the mean scores ranged from 4.73 to 5.22 with an average of mean scores of 4.93. The researcher also conducted a One-sample Wilcoxon Signed Rank Test on the mid-value (4) for each question. It revealed a statistically significant difference ($p<.001$) in the median value of responses and the mid-value in all the questions. Moreover, a Mann-Whitney U Test revealed no significant difference in the confidence level of applying project-based learning in STEM education between primary school teachers and secondary school teachers. Table 3 shows teacher's confidence in different dimensions to instruct students' STEM project. The mean values range from 4.83 to 5.07.

Table 2. Descriptive statistics of Q1-Q14.

	N	Minimum	Maximum	Mean	Std. Deviation
Q1	37	3	7	4.84	.928
Q2	37	2	7	4.73	1.045
Q3	37	2	7	4.95	1.079
Q4	37	3	7	4.92	.894
Q5	37	4	7	5.22	.750
Q6	37	3	7	4.95	.815
Q7	37	2	7	5.05	1.104
Q8	37	3	7	5.00	.913
Q9	37	3	7	5.00	.882
Q10	37	3	7	4.86	.948
Q11	37	3	7	4.89	.875
Q12	37	2	7	4.84	.958
Q13	37	2	7	4.92	1.038
Q14	37	3	7	4.92	.894
Valid N (listwise)	37				

Table 3. Teacher's confidence in different dimensions to instruct STEM project.

Dimension	Mean
Confident to help students …	
Organize the challenge in the inquiry (Q1 & Q4)	4.88
Engage in the inquiry learning process (Q8 & Q9)	5.00
Explore the knowledge embedded in the inquiry (Q3 & Q10)	4.91
Reflect on what they have learnt and connect it to the inquiry (Q6 & Q11)	4.92
Derive explanations of their claims (Q7 & Q12)	4.95
Develop a scientific understanding of the inquiry (Q2 & Q13)	4.83
Share the results of the inquiry (Q5 & Q14)	5.07

5 Discussion

Research has suggested that STEM education is beneficial to learners and society in this technology-oriented era (Saxton et al., 2014). To successfully implement STEM education, teachers' confidence to teach an integrated STEM subject is a critical factor. Among the various pedagogical methods, a project-based learning approach has been encouraged to promote STEM education (Education Bureau HKSAR, 2016). In-service teachers in Hong Kong are expected to apply project-based learning to nurture students in STEM education. As reflected by the overall mean scores of 4.93, the confidence level of instructing STEM projects is only slightly about the mid-value (4) in the response range of 1 to 7. It suggests that the in-service teachers were not very confident to apply a project-based learning approach to promote STEM education. This result aligns with the study by Han et al. (2015) and Smith et al. (2015) the teachers lacked confidence and could not effectively instruct students' STEM projects, even though they may have received relevant training.

Regarding teacher's confidence in different dimensions to instruct STEM project, it is not surprising that the teachers were more confident to help students engage in the inquiry learning process and share the results of the inquiry using different tools. These two dimensions are regarded as some generic teaching skills that are not specific to STEM education. The weakest dimensions are the confidence to help students organize the challenge in the inquiry and develop a scientific understanding of the inquiry. It suggests that teachers may not have sufficient knowledge across STEM and, therefore, found these teaching tasks challenging. Since most teachers focused on a specific discipline in their university studies, it is difficult for them to teach integrated STEM subject due to the interdisciplinary nature of STEM. These results strengthen the findings by the study of Margot and Kettler (2019) and Shernoff et al. (2017) that teachers lack sufficient knowledge and skills to teach STEM.

Moreover, there is no statistically significant difference in the confidence level between primary school and secondary school teachers on the application of the project-based learning approach in STEM education. It suggests that no matter in-service primary or secondary teachers in this study, all of them were not confident enough to apply a project-based learning approach to engage students to learn STEM.

6 Conclusions

Given the results, although project-based learning is encouraged for STEM education, teachers of primary and secondary levels in Hong Kong are not very enough to apply this pedagogical approach and it reflects that they need more training. Particularly, teachers should enhance their competence to help students organize the challenge and develop a scientific understanding of the inquiry. Moreover, teachers are also required to strengthen their knowledge in STEM and project-learning teaching skills to assist students to explore the knowledge embedded in the inquiry, reflect on what have learnt and connect it to the inquiry, and derive explanations of their claims.

With the results reported, some limitations existed in this study. The sample size is relatively small and the participants are regarded as convenient samples. Moreover, this study mainly used a self-reported questionnaire to consult the confidence level of the in-service teachers. The researcher did not investigate the actual performance of the teachers in implementing project-based learning in STEM education. Therefore, academics could conduct a similar study in the future with larger and more random samples. It would also be meaningful to investigate the actual performance of teachers concerning their application of project-based learning in STEM education. Notwithstanding the existence of these limitations, this study provides evidence that in-service teachers of both primary and secondary levels in Hong Kong require more training in using a project-based learning approach for the success of STEM education.

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The Integration of WSQ Knowledge Constructing Approach for Supporting Students' STEM Science Learning

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Abstract

Purpose – STEM education provides opportunities for hands-on work, which enables students to acquire higher-level thinking skills and complex scientific problem-solving skills. For science knowledge acquisition in STEM education, except learning from doing the project, integrated knowledge-building activities during STEM activities are essential.

Design/methodology/approach – To this end, this study adopted the Watch-Summary-Question (WSQ) approach to help students construct knowledge before their STEM project. In the WSQ procedure, the approach guided students to watch and acquire science knowledge. Then, they summarized important knowledge content. After summarizing the content, students raised questions related to the topics. It was expected that the WSQ approach could help students check whether they fully understood and applied the knowledge. To examine the effectiveness of the WSQ approach, we conducted an experiment in a university STEM course. This course instructed students to make cosmetics. We recruited 20 students as the experimental group, and they used the WSQ-based STEM learning mode. The other class, the control group (22 students), was conducted in the conventional STEM learning mode.

Findings – The results show that the experimental group outperformed the control group in learning achievement. At the same time, students in the experimental group performed better than did the control group in deep learning strategies. In the drawing test, it was found that students in the experimental group performed better in sanitation, materials and instruments, positive emotion, and notice after the drawing analysis.

Originality/value/implications – This study proved that the WSQ knowledge construction approach can enhance students' understanding of science by guiding them to acquire knowledge and raise questions, thus improving their performance. Through the knowledge construction approach, students may improve their problem-solving skills by making connections across domain knowledge during the learning process.

Keywords: STEM, knowledge construction, technology-assisted learning

1 Introduction

STEM education was considered to be an important educational issue (Fan & Yu, 2017). Generally, it includes science, technology, mathematics, and engineering. It emphasized the enhancement of students' practical skills and scientific literacy. In the process of practice, students gained the abilities to face complex scientific problems (English, 2017). In past studies, students have improved their learning outcomes, higher-order thinking, problem-solving, and collaborative communication skills during STEM learning (Evans et al., 2020; York et al., 2019).

STEM education has various activity modes which depending on the teaching objectives. For example, STEM activities that focused on programming education often guided students to use technology and programming to solve problems in their lives. STEM activities that focused on the environment and ecology often used a project-based learning model that guides students through data collection and problem solving. STEM education can also aim to develop students' scientific skills though producing scientific products. According to Yu et al. (2020), students' knowledge learning and critical thinking experiences during the hands-on process would influence the final product. Students had to integrate their scientific knowledge, reasoning, interpretation, and evaluation to complete the final product. Therefore, science practice is an important activity that connects students' scientific knowledge and skills (Pinger et al., 2020). These hands-on tasks test students on a variety of abilities, including scientific cognition, spatial understanding, object configuration, and sequencing.

In STEM hands-on activities, students were required to apply different knowledge, including conceptual and process knowledge. In particular, hands-on science activities were often associated with more difficult and abstract concepts. If the knowledge was not constructed with certainty, students would not only have difficulty completing the hands-on curriculum in a limited time but would also be less confident to continue learning science in the future (Seery et al., 2019). Therefore, researchers have identified this difficulty and pointed out the need to encourage students to construct knowledge in the STEM learning process.

2 Literature Review

2.1 STEM education

STEM education is an activity that combines the disciplines of science, technology, engineering, and mathematics. Learners engaged in scientifically meaningful learning in this process (Carlone & Johnson, 2007). Students were not only science learners but also engineering creators in the learning process. Simpson and Bouhafa (2020) suggested that STEM education not only helped individuals learn but also had relevance to students' future careers.

In the STEM education model, active learning was achieved and students played an active role in learning knowledge and problem-solving. Researchers have confirmed that the use of STEM education methods could increase students' motivation and academic performance (Freeman et al., 2014), and also improved students' knowledge retention (Beier et al., 2019). As described by Torres et al. (2016), during the STEM learning process, students constantly focused on specific problems or real-world issues. Therefore, in this process, students experienced a real-world problem-solving learning process that would enhance retention and higher application of knowledge.

Wang and Chiang (2020) developed an activity for students to learn about engineering and construct engineering models. The activity emphasized students' self-construction of knowledge and task completion. Students identified problems and gained knowledge during the course. Solutions were designed, tested, and implemented based on this knowledge. The results of the study confirmed that cross-disciplinary learning and application enhanced students' learning attitudes. In addition, students showed a more sustained and positive learning experience.

2.2 Knowledge Construction

Knowledge construction was an activity in which learners organized existing or collected data around them into information and internalized it into knowledge (Peng et al., 2009). Knowledge construction has shown a positive impact on students' learning of science (Chen & Hong, 2016). The activities and forms of knowledge construction were quite diverse, including face-to-face, online, collaborative, curriculum-based, and project-based (Lau et al., 2017; Sung & Hwang, 2018). In the process of inquiry and knowledge construction, students continued to refine their concepts (Bereiter, 2005).

Knowledge construction has been successfully applied to many disciplines (Chen & Hong, 2016). In science learning, for example, past studies related to knowledge construction included students' collaborative learning and the relationship between knowledge construction activities and understanding of science (Goh et al., 2013; Hong et al., 2015). In addition, Li et al. (2020) analyzed students' performance in the knowledge construction process and found that students used knowledge construction learning methods to form more complex scientific concepts. It also improved the quality of students' scientific inquiry and opportunities for interaction.

In STEM education, students did not only learn knowledge, but also need to categorize different learning concepts, carry out projects, and evaluate the results. For students, this was a complex cognitive learning process. In addition to acquiring knowledge through hands-on problem solving, students need knowledge construction tools to help them organize their knowledge.

2.3 Knowledge Construction Approach

It was necessary for students to have the assistance from teachers or other scaffolding in the process of knowledge construction. Kirch (2012) proposed WSQ (Watch-Summary-Question) as a strategy to guide students to take notes, summarize their knowledge, and ask questions based on what they have learned. Lin and Hsia (2019) proposed the ASQI (Annotation, Summarizing, Questioning, Interflow) flipped learning method. The results showed that the ASQI strategy significantly improved students' billiards ability and online learning engagement. Also, according to student feedback, ASQI helped students use strategies effectively and improve academic performance.

In the process of STEM science practice, it was necessary not only to train students' skills but also to apply the knowledge learned to solve problems. Therefore, this study used the WSQ knowledge constructing approach to help students understand scientific concepts and practice processes. To investigate the effectiveness of this learning approach, this study conducted an empirical study to compare students' learning performance with that of using conventional STEM learning activities. The research questions for this study are as follows.

1. Do students use the WSQ knowledge constructing approach have different STEM learning outcomes than students use conventional STEM learning activities?
2. Are there differences in deep learning strategies between students who use the WSQ knowledge constructing approach and those who use conventional STEM learning activities?
3. Is there a difference in the content produced by students using and not using the WSQ knowledge constructing approach?

3 System Development

To support students' STEM science practices, a STEM learning activity based on the WSQ knowledge constructing approach was developed. In this learning model, students went through five stages, including watching, summarizing, asking questions, doing, and discussing.

Before the course starts, students tested the system and e-books on their smartphones or tablets. The WSQ learning activity began after the teacher confirmed that all students could read the e-book. In the watching stage, students watched an interactive e-book. The content of the interactive e-book included text descriptions of knowledge content, interactive pictures, interactive exercises and question and answer mode. Students could learn about hyaluronic acid and polymers in the e-book. Students also learned the correct steps and precautions for weighing materials through the interactive e-book. In addition to the learning content, the system also provided quizzes to check whether students understood the knowledge. The purpose of the activity was to let students understand the role of hyaluronic acid in skincare products and how to prepare hyaluronic acid solution. Thus, during the watching process, the system guided the students to solve the tasks. If the student could not complete the task correctly, the system would provide feedback.

After watched the e-book, the students did a summarizing activity. In this step, students were guided through the system to summarize their knowledge. Then they uploaded their summaries to the learning platform. In the summary phase, students completed three tasks on the system, including a detailed explanation of the process of preparing hyaluronic acid solution, an explanation of the uses of hyaluronic acid, and the error-prone parts of the process. After the students completed the knowledge summary, they uploaded the data to the teacher interface. The teacher verified that the students have understood the important learning based on the content they have uploaded.

After completing the summarization phase, students were guided through the questioning phase. During the questioning phase, students had to asked one to three questions. These questions must be related to the learning content, preparation process, or application. When students have completed the watching, summarization, and questioning phases, they then proceed to the STEM activity. After the STEM activity, the students discussed and shared the finished product.

On the other hand, the control group students learned using conventional STEM learning activities, and the interactive e-books developed in this study would also be used for their learning. After the students watched the e-book, the teacher summarized the process of preparing the hyaluronic acid solution, the uses of hyaluronic acid, and the error-prone parts of the process.

4 Research Method

To evaluate the effect of the WSQ knowledge constructing approach on students' learning achievement in science STEM, a quasi-experimental design was used in this study. Students in the experimental group used the proposed method. The control group used conventional STEM learning activities. This study would analyze the students' STEM learning performance and the tendency of deep learning strategies. In addition, the post-test content drew by experimental and control group was analyzed by drawing analysis method.

4.1 Participants

The participants in this study were from the university in northern Taiwan. A total of 42 university students took part in this study. They were between the ages of 18 and 20 and were recruited from two classes. The curriculum was the same for both classes and comprised a 4-week STEM activity design and comprehension course taught by the same teacher. One class was assigned as the experimental group of 20 students, which used the WSQ knowledge constructing approach to teach the hands-on STEM curriculum. The other class was assigned to a control group of 22 students, which used conventional STEM learning activities. Each student completed the STEM product independently.

4.2 Measuring Tools

In the pretest, students were asked to draw an example of a STEM activity in which they had taken part in. The test was administered using Yeh et al.'s (2019) approach, in which students were asked to describe their understanding of the STEM learning model graphically. The scoring criteria included the level of detail of textual descriptions (15 points), clarity of graphic descriptions (15 points), consistency of textual and graphic content (15 points), integration of content with previous experiences or teaching examples (20 points), and appropriateness of technology choices (20 points). The inter-rater reliability of the pre-test was 0.86. The post-test was administered after the STEM activities to examine students' understanding of the STEM activities. The teacher and an expert familiar with STEM activities rated the student's drawings for accuracy of the process (25), clarity of expression (25), scientific concepts (25), and overall visual performance (25) to ensure the validity of the test. The inter-rater reliability of the post-test was 0.85. The deep learning strategy questionnaire developed by (Lee et al., 2008) was used in this study to understand the students' deep learning strategy tendency. The Cronbach's alpha value of the original questionnaire was 0.89.

The drawing analysis was coded by the teacher and another expert familiar with STEM activities. The content was divided into Sanitation (4 points), Materials and Instrument (6 points), Preparation Process (10 points), Positive Emotion (1 point), and Notice (1 point). The inter-rater reliability (Cohen's kappa) value for the drawing analysis was 0.87.

4.3 The Experimental Procedure

To ensure that the students understood the STEM activity process, the teacher conducted a 30-minute pre-test for the experimental and control groups during the first week and then introduced the students to the 10-minute learning process. Students in the experimental group then watched the interactive e-book on STEM activities. After watched the e-book, students did a summary activity and finally asked questions to complete the WSQ knowledge constructing activity. After the control group students watched the e-book, the teacher summarized and explained the error-prone parts. The WSQ knowledge constructing activity and the STEM practice session took 260 minutes. In the fourth week, both groups took a 90-minute post-test and completed the post-test questionnaire in 10 minutes.

5 Result

5.1 Learning Performance

The purpose of the pre-test was to ensure that the experimental group and the control group had the same understanding of the cognitive model of STEM learning. Therefore, ANCOVA used for the analysis. Table 1 shows that the post-test performance of the experimental group was significantly better than that of the control group (F = 10.77, $p < .01$). The adjusted mean for the two groups was 81.27 (experimental group) and 65.21 (control group), respectively. The results showed that students who used WSQ knowledge constructing approach performed better than those who used conventional technology-assisted learning in drawing test.

Table 1. ANCOVA analysis of scores in post-test

Group	N	Mean	SD	Adjusted Mean	Adjusted SD	F
Experimental group	20	80.50	14.13	81.27	3.53	10.77^{**}
Control group	22	65.91	18.69	65.21	3.36	

$^{**}p < .01$

5.2 Deep Learning Strategy

The results of students' deep learning strategy were shown in Table 2. In this study, the Mann-Whitney U test was used to analyze the students' deep learning strategy after learning. The results indicated that students using the WSQ knowledge constructing approach performed better in the deep learning strategy than the conventional technology-assisted learning group (U = 138.00, Z = -2.09, $p < .05$) with a medium-large effect size (d = 0.72).

Table 2. The Mann-Whitney U test of scores in deep learning strategy

Group	N	Mean	SD	U	Z	d
Experimental group	20	4.03	0.54	138.00	-2.09^{*}	0.72
Control group	22	3.68	0.42			

$^{*}p < .05$

5.3 The Result of Drawing Analysis

This study aimed to find out whether there were differences in the items drawn by the experimental and control groups in the content of the drawings. Therefore, the Mann-Whitney U test was used to analyze the students' drawing tests. The results showed in Table3 and the experimental group had different scores in sanitation (U = 138.00, Z = -2.09, $p < .001$), materials and instruments (U = 140.00, Z = -2.95, $p < .01$), positive emotion (U = 163.00, Z = -2.02, $p < .05$), and notice (U = 153.00, Z = -2.48, $p < .05$) outperformed the control group. Positive emotion had a medium-large effect size (d = 0.65), and the effect size of sanitation (d = 1.7), materials and instruments (d = 0.95), and notice (d = 0.8) were large effects size.

Table 3. The Mann-Whitney U test of scores in drawing analysis

Term	Group	N	Mean	SD	U	Z	*d*
Sanitation	EG	20	1.80	0.95	59.00	-4.31^{***}	1.7
	CG	22	0.36	0.73			
Materials and Instruments	EG	20	6.00	0.00	140.00	-2.95^{**}	0.95
	CG	22	5.55	0.67			
Preparation Process	EG	20	6.10	1.92	210.00	-0.26	
	CG	22	6.00	1.69			
Positive Emotion	EG	20	0.35	0.49	163.00	-2.02^{*}	0.65
	CG	22	0.09	0.29			
Notice	EG	20	0.35	0.49	153.00	-2.48^{*}	0.8
	CG	22	0.05	0.21			

**p < .05, **p < .01, ***p < .001. EG experimental group, CG control group.*

6 Discussion and Conclusion

In STEM activities, it was helpful to provide students with knowledge construction tools before the activity flow. Therefore, the WSQ knowledge constructing approach was used to help students construct knowledge and skills before the STEM activities. The results revealed that the experimental group outperformed the control group on post-test and deep learning strategies. The experimental group performed better on sanitation, materials and instruments, positive emotion, and notice after the coded drawing test.

The WSQ knowledge constructing approach could help students improve their understanding of science, as evidenced by their learning performance. The WSQ approach not only improved students' knowledge and skill performance but also facilitated students to connect different learning contents. This study further confirmed that watching, summarizing, and asking questions could provide students with a comprehensive understanding of the process and improving student learning outcomes

(Cui & Yu, 2019).

This study used the WSQ knowledge constructing approach as a knowledge construction tool. The results showed that the WSQ approach helped students to construct knowledge during STEM learning. Therefore, the different knowledge construction tools could be used for different sample sizes or learning topics.

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No Pain, No Gain: The Necessary Initial Struggles to Enable Doctoral Research Work

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Abstract
Purpose – This paper reports on experiences at the start of a software engineering (SE) PhD, where the candidate encountered and overcame multiple challenges in setting up his research environment, which included online learning (and supervision) elements. When preparing a replication study, the candidate faced both hardware and software problems as he lacked the necessary equipment and the experience to run the project. Eventually, the candidate changed his mindset to see challenges as opportunities, reached out to various others to seek advice, and identified solutions for his problems. This paper shares these (necessary) challenging experiences, and the insights gained from them. As an integral part of the development of doctoral study skills, this paper may help other students, advisers, and administrators to be aware of, and prepare for, these challenges.
Design/methodology/approach – The various experiences are reflected on by the PhD candidate, and examined and analysed by him, his academic advisers, and other relevant stakeholders. Comparisons are drawn with similar doctoral candidates, and other related experiences recorded in the literature. The unbounded nature of the problems encountered at the start of the doctorate was a shock to the candidate, and required expanding his perception of the problem- (and solution-) space, and the fast development of new problem-solving skills. Supported by his advisers, the candidate unknowingly followed a self-directed, exploratory learning framework, making use of online learning techniques and resources.
Findings – The candidate reports that he now knows the importance of seeking help when unable to solve a problem. Through identification and communication with a mentor, the student has also seen the value of presenting perceived challenges quickly and accurately. While overcoming challenges, he learned to brainstorm, and control panic, thus strengthening his independent researcher potential. Another potentially culturally-related insight is the professed importance of prompt honest communication with the adviser, who — unlike the undergraduate assessor role — has more responsibility for guidance and giving advice. Although our findings relate to experiences prompted by an SE replication study, they will resonate with many other research situations.
Originality/value/implications – Challenges are common at the start of a PhD, but there is little in the literature explicitly discussing this, or the necessity of overcoming them to enable doctoral study. This paper proposes a framework that can provide guidance for both PhD students and supervisors. It also serves as a reminder to relevant administration staff of the provisions needed to enable, and ensure that the PhD candidate emerges ready, mentally and skill-wise, from the experience.

Keywords: doctoral preparation; doctoral training; mental health; student-challenge expectations; student support structures.

1 Introduction

1.1 Background

Although many doctoral students are enrolled each year, current literature addressing the transition to doctoral studies from other degrees is limited (Heussi, 2012; Tobbell, O'Donnell, & Zammit, 2010). It is common that PhD students experience challenging transitions in their first year of study (Cluett & Skene, 2006; Crane et al., 2016; West, 2012), which could be caused by many factors. For instance, the expectations of the presumptive competence of individual learning can decrease the confidence and increase the feelings of isolation in postgraduate students, which may adversely affect the transition trajectory (Tobbell & O'Donnell, 2013a). Symons (2001) showed that some university staff have a limited understanding of the problems students will encounter during their transition to postgraduate level and believe that they do not need induction as they are already experts as students. As a matter of fact, many postgraduate students may need to work in the areas that are very different to the academic discipline they studied at their undergraduate level (O'Donnell, Tobbell, Lawthom, & Zammit, 2009). Furthermore, international students may also experience challenges in daily life such as social isolation, cultural shock or an unfamiliar academic environment in their first year, which will make their transition more difficult (Hall & Wai-Ching Sung, 2009). If PhD students who are in trouble do not get enough help and attention, it may cause serious problems for their mental health, research outcomes and even have a negative impact on other peers and staff (Danna & Griffin, 1999; Levecque et al., 2017).

This paper describes the experience of a PhD candidate who overcame challenges to set up his research environment, such as lack of experiment devices, and how he adapted himself to the postgraduate level of study to pass through the transition period. Additionally, this paper proposes a framework for students on how to overcome challenges with the integration of the self-directed learning concept, which is a type of study that the learner takes the initiative, with or without the help of others, to organize his learning activities (Knowles, 1975), derived from the candidate's experience of unknowingly implementing this concept into his daily research.

Another factor that may help the candidate to get through is honest, effective communication with his supervisor. Research shows that successful students benefit most from active supervision (Deuchar, 2008), and students' perceptions of how well they will transit through the degree depend heavily on effective communications with academic staff (Bownes et al., 2017). Although doctoral supervision plays an important role in the success of PhD students, many students may have trouble with how to get along with their supervisors (Austin, 2002; Vilkinas, 2008). Therefore, advice for students on how to develop "healthy" relationships with their supervisors is offered in this paper as well, while the word "healthy" here refers to both supervisors and students are working as expected within the scope of doctoral supervision.

1.2 Structure

This paper is structured as follows. Section 2 gives a literature review about the existing studies for the transition to postgraduate level of study, self-directed learning and doctoral supervision. Section 3 describes the experience of the candidate in the first year as a PhD student, explaining how he adapted and overcame difficulties. Section 4 outlines the findings of the candidate after one year of studying. It also proposes a framework for students to handle challenges and maintain “healthy” relationships with their supervisors. Section 5 concludes the paper, and discusses some potential future work that may be performed.

2 Literature Review

2.1 Transition to postgraduate level of study

The difficulties that students may encounter when transitioning from lower degrees to doctoral studies have been ignored for a long time. Although there have been many studies focusing on how to help students become successful in their first year of university (Baik, Naylor, & Arkoudis, 2015; Kift, 2009), materials for the transition to postgraduate, especially doctoral, level are scarce (Tobbell & O’Donnell, 2013b; Heussi, 2012; Tobbell, O’Donnell, & Zammit, 2010).

Although there maybe assumptions that doctoral students should not experience a large difference in the learning environment since they are already somewhat experts in the domain of higher education (Tobbell, O’Donnell, & Zammit, 2010), this in fact, may not be correct: West (2012), for example, found that more than half of students with an undergraduate degree thought the transition process was challenging. In addition, eighty percent of PhD students surveyed found the coursework in their first year to be overwhelming (Cluett & Skene, 2006). One research conducted in 2016 among 319 postgraduate students found that students did not receive adequate support during the transition to postgraduate studies (Crane et al., 2016). Therefore, more understandings is needed of the difficulties faced by students transitioning to be postgraduate students (Tobbell, O’Donnell, & Zammit, 2010).

If the situation is not handled well, it may cause severe problems to postgraduate level of students, either mentally or physically. A study held by Levecque et al. (2017) based on 12 mental health symptoms (GHQ-12) found that about one-third of PhD students have a potential risk of suffering from psychiatric disorder, particularly depression. The difficulties that students may encounter during transitions to doctoral studies have been ignored for a long time. Although there are many studies about how to help students become successful in their first year of university (Baik, Naylor, & Arkoudis, 2015; Kift 2009), similar investigation of the transition to postgraduate level is scarce (Tobbell & O’Donnell, 2013a; Heussi, 2012; Tobbell, O’Donnell, & Zammit, 2010).

Therefore, it is significant and worthwhile to examine on how to handle the challenges encountered during the transition process to doctoral studies, which is what this paper aims to do.

2.2 Self-directed learning

Self-directed learning (SDL) is a concept to describe a type of study. There are many definitions of SDL, from different perspectives (Loeng, 2020), and several models have been proposed to help examine and understand it (Candy, 1991; Brockett & Hiemstra, 2018; Garrison, 1997). For instance, Candy (1991) proposed a four-dimensional model for SDL that includes personal autonomy, self-management, learner-control and autodidaxy. Brockett and Hiemstra (2018) created a model called "Personal Responsibility Orientation" (PRO) to see SDL in two directions to help understand the concept. The first direction defines SDL as a process "in which a learner assumes primary responsibility for planning, implementing, and evaluating the learning process" while the second direction defines it as a goal to be "a learner's desire or preference for assuming responsibility for learning". Similarly, Garrison (1997) proposed a three-dimensional model that includes self-management, self-monitoring, and motivation, which focuses on the use of resource and learning strategies, as well as the motivation to study. A common perspective for most conceptualizations is the self-control of the planning and management process in the learning experience (Garrison, 1997). This paper follows the definition that was proposed by Knowles (1975, p.18):

> In its broadest meaning, self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes.

In other words, the learner shall take responsibility for their cognitive development, with or without others help. This can be divided into four processes: tasks defining, goals setting and planning, process monitoring, and reflecting (Knowles, 1975; Winne & Hadwin, 1998). Process monitoring refers to monitor those processes that could represent the metacognitive awareness of the learner, which is an important ability to help him understand the effects of learning such that the efficiency may be improved in the future (Schraw, 1998). Reflecting refers to the self-evaluation conducted to document the performance and assess the strength and weakness that needs to improve. There are some models in the literature proposed to help the learner perform reflective practice (Borton, 1970; Argyris & Schon, 1978; Gibbs & Great Britain, 1988). Considering the difference of postgraduate degree to others, self-directed learning has become an important and necessary ability for PhD candidates.

2.3 Doctoral Supervision

Effective supervision plays an important role in the success of PhD students (Vilkinas, 2008). Research has examined individual and joint supervision in doctoral education (Barnes & Austin, 2009; Heussi, 2012; Sambrook, Stewart, & Roberts, 2008; Lahenius & Ikävalko, 2014).

Some studies have attempted to characterize the theory of supervision and the roles supervisors shall play (Lee, 2008; Halse & Malfroy, 2010; Vilkinas, 2008). Although differences exist, there are some common factors shared among them. For example, both supervisor(s) and student should work toward the same goal based on mutual respect and a firm commitment (Lahenius & Ikävalko, 2014). Supervisors should provide reliable information and be the social bond between student and the department and occupation (Barnes & Austin, 2009). Halse and Malfroy (2010) summarized the work of supervision that supervisors should be an expert on providing learning alliance and help the student understand the discipline of research and institutional context of doctoral study.

However, even though supervisors are essential to doctoral students, sometimes the relationships might go wrong (Austin, 2002). For instance, both sides may lack trust in each other, or fail to reach mutual expectations (Fagen & Suedkamp Wells, 2004). The existing literature indicates that good relationships and interactions between supervisors and students are the critical factors for those who took less time to complete their degrees (De Valero, 2001; Seagram, Gould, & Pyke, 1998), with students reporting the greatest benefits being from the active supervisions (Deuchar, 2008). Therefore, this paper also aims to help guide how to develop a good relationship and maintain effective interactions for both students and supervisors.

3 Experience

3.1 Making Connections with multiple people

Due to the lack of experiment equipment at the beginning of the semester and the analysis of the current devices, the candidate had to brainstorm solutions, and the first idea that came out was asking for others' help. This was the first challenge the student encountered during his PhD career since he had to do this independently, in contrast to his undergraduate studies, when the teachers usually prepared everything. The IT Department was the first idea came out of his mind due to their work characteristic. However, they could not provide an extra device as every PhD student had already been assigned with a computer, which failed to meet the requirements of the candidate.

Although this was unexpected, the student had to search for other solutions. The Library was his next stop as he was lucky to know that there was a new lab just finished construction, which has equipped with computers that suited his needs. After queries, he was finally introduced to a library administrator for Research and Learning in the Library. Although the administrator attempted to help, eventually it was not possible, as the relevant computers were reserved for public use only.

In addition to the people mentioned above, the student has tried to contact several other academic staff, but none could provide help because of personal and regulatory reasons. Such a series of failures have largely decreased the motivation of him. Thankfully, his supervisors have been accompanied with him all the time and encouraged him to brainstorm solutions with an open mind. For his supervisors to understand the situation he was facing, the student tried to write down his reflections without reservations in the weekly report and behave honestly in the meetings. Finally, perseverance paid off. The student managed to reach a professor through the introduction of his supervisor, who was willing to lend one of the computers in his lab, which solved this initial problem. **Fig. 1.** shows the result of brainstorming for the above progress, in which the sentences in bold and italic refer to the possible solutions and measurement criteria, respectively.

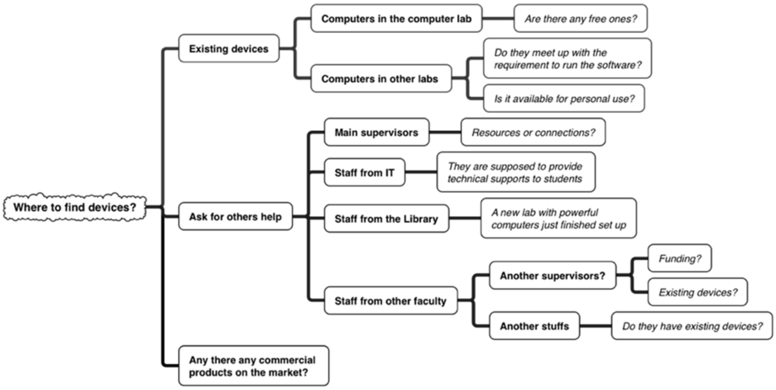

Fig. 1. Brainstorm process of finding the computer

3.2 Self-directed learning: The only way to survive and thrive

The candidate unknowingly implemented the self-directed learning concept into his research through a process iterated weekly. This consisted of four parts: defining, planning, monitoring, and reflecting (Knowles, 1975; Winne & Hadwin, 1998).

The first part in this iteration was the defining of the tasks the student should solve for now. It was usually done based on the analysis of the challenges he had, the progress he had already made, and other works he needed to do outside the project, for instance, part-time jobs. He then sorted them in order from primary to the least significant based on the effect they had on the overall progress.

After defining tasks, the student needed to set goals and make a plan. Considering the time and energy to be put on the project, the plan needed to be made neither too easy such that it would take few hours to finish, nor too hard that could influence other works the student was working on at the same time.

The third and fourth steps were performed usually at the end of the week. The student monitored the processes that could represent the metacognitive awareness and recorded them for future review. Then he reflected the entire progress made in this week, recorded the aspects that were not done properly with the emotional changes, and wrote it down into a document.

At the beginning of each week, the student listed all the challenges he had, reviewed the progress he had already made, and decided what tasks shall be finished in this week. He then grouped them into a report with the reflections of the last week and brought it to the weekly meeting with his supervisor, who would give opinions on it and provide guidance if needed. **Fig. 2.** shows one page of the weekly report as an example.

Weekly Report Gabriel

Date: 2020/11/16
Week: 8

General Review

Last week I mainly followed the plan made in the weekly report. However, the work needed to be done before the replication process was underestimated such that I was not able to finish the experiment on time. Specifically, there were different problems that occurred every day, and some of them were solved the next day while some were not. Fortunately, the current progress has approached to the extent that the replication experiment can be done.

What I have done

I have made running logs in the last week and I put them in the appendix in the below section.

What I will do in this week

Currently, I have proceeded into the first step of replicating the research, i.e. extracting point cloud data from the recording. I will try to finish the second and third steps this week, which are manually adding noise outside the region of ROI and gathering data. Since the system version is different from the original ones that were used two years ago, there are many files and functions that have also been changed. Therefore, there would be challenges to re-perform the experiment, just like the situation in the previous week.

Self-Reflection

It took me three days to realize that the plan made in the last weekly report was too optimistic. The effect of the difference between system versions is underestimated. I have read a lot of issues published on the Apollo GitHub page and also post several ones. Fortunately, there is some progress that I found the old data bag used two years ago and was able to transform it into the form that the current system version can use. I think another reason why the speed is not fast is that it takes several minutes every time Apollo builds itself.

Appendix

20201111

Challenges

- Still cannot solve the problem of the perception and traffic light module accidently switch on and off without control
  - have already submit this problem to the GitHub community of LGSVL; currently still exchanging information

1

Fig. 2. Sample page of a weekly report by the PhD student

3.3 Online communication and learning

As the work of the PhD candidate was highly specialized, which relied on uncommon software and hardware, it could be hard to find specific resources to help or assist learning. This was in contrast to undergraduate assignments which were well defined and lots of resources were available online and elsewhere. For the candidate, online communication was convenient, but it had a lot of uncertainties. For instance, he managed to get in touch with a peer who had experience on setting up the software environment with the help of his supervisor on the Internet. When encountering problems he could not solve, he would post it on the forum quickly but the waiting time was sometimes so long that would slow down the overall progress and there was almost nothing he could do. Such kind of situations had forced him to develop the abilities of brainstorming and finding alternative strategies to reach the same goals, in other words, “Don’t put all your eggs in one basket” (GoEnglish, n.d).

4 Findings

4.1 Findings through the candidate’s own experience

After one year of studying, there are three lessons the candidate has learnt. The first lesson is the professed importance of prompt honest communication with the supervisor, who, unlike the undergraduate assessor role, has more responsibility for guidance and advising. It enables an emotional connection to be built between supervisors and students such that mutual understanding of the situation can be reached faster and easier. Meanwhile, it helps him develop a good relationship with his supervisor, which, as described before, is crucial to the success of doctoral students (De Valero, 2001; Deuchar, 2008).

The second lesson the candidate learnt is the necessity of perseverance with right skills and strategies. Since it is common for PhD students to face challenges (West, 2012), emotion control is essential to allow him to perceive the dilemma quickly. Additionally, the abilities of brainstorming and accurately presenting perceived challenges are crucial to the final answer as the former helps the generation of creative ideas while the latter can make clearer thinking and more efficient communications.

The third aspect the candidate finds useful is the habit of good documentation. Good documentation can enable him to review and reflect regularly, which also helps the he develop metacognitive awareness. Additionally, it can be reused in the dissertation or other paperwork such that the time and energy of him can be saved.

4.2 A framework guides students on how to handle challenges

This paper proposes a framework to help students better handle challenges with their supervisors. **Fig. 3.** presents the detailed flowchart with the implementation of the self-directed learning concept.

The flowchart starts with the time when students encounter new problems. As a PhD student, it is essential to realize that problem-solving is a part of the doctoral study process. Therefore, emotion control is the primary action he shall perform. If there is a problem with that process, it is recommended to record it in a document for future discussion, as the “monitoring and reflecting” process in the concept of self-directed learning (Knowles, 1975; Winne & Hadwin, 1998).

After successfully controlling the emotions, the next task is to brainstorm the solutions and analyse the situation. It is suggested for the students to list his progress and prioritize problems that need to be solve. The former can enable a better understanding of his achievement and improve his confidence; while the latter may help prevent interruptions by other unrelated tasks. This process corresponds to the “defining and planning” process described in the self-directed learning concept (Knowles, 1975; Winne & Hadwin, 1998). If the problems can be solved with the solutions generated, then recording to the document for future reflection is recommended; otherwise, it needs to go to the next phase where external assistance is required.

If the students cannot figure out solutions, or the strategies fail, it is important to find assistance instead of giving up, which would negatively impact his process and emotions. The first choice should be the supervisors, who aim to help and guide, according to the rules of supervision (Halse & Malfroy, 2010). This process requires honest communication to build a mutual understanding of the dilemma, which should be based on the premise of mutual respect and sharing the same goals between both sides, as described in the theory of supervision (Lahenius & Ikävalko, 2014). For supervisors, at this stage, encouraging and motivating the student may be of primary importance (Deuchar, 2008). Because supervisors typically have more resources than students (Halse & Malfroy, 2010), including knowledge and connections, they should be able to guide students and find a solution together.

However, even though turning to supervisors is necessary and vital, students should not limit themselves to that only approach. While communicating with supervisors, they should find possible people who can provide assistance, for instance, peers and staffs. They can also publish the questions on the Internet if they find there are no similar ones before. No matter the problems are solved or not, students shall document the process. In addition, while waiting for the answers, students shall try to find any other parallel tasks to do instead of wasting their time.

The whole procedures described above is the framework this paper proposed to help students handle challenges based on the experience of the candidate and the concept of self-directed learning. Furthermore, it is not limited to natural science students but other students from different majors and levels of study.

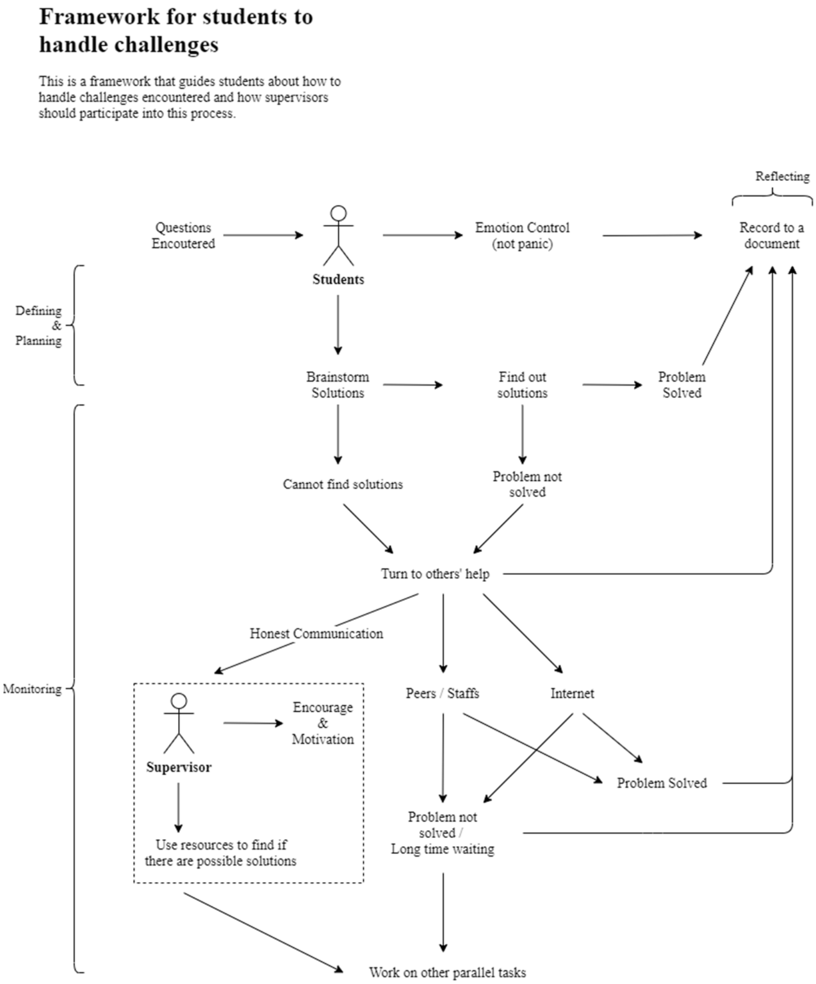

Fig. 3. Framework for helping students handle challenges

4.3 How to maintain "healthy" relationships with supervisors

Although there are multiple research studying the student-supervisor relationship (Styles & Radloff, 2001; Hodza, 2007; Mainhard, van der Rijst, van Tartwijk, & Wubbels, 2009), this paper offers some general suggestions on maintaining "healthy" relationships with supervisors, from the student perspective, which the word "healthy" here refers to both supervisors and students are working as expected in the range of doctoral supervision. There are three points the author believes are worth paying attention to:

1. Be honest and respect supervisors. This is the foundation of developing mutual trust and performing effective communications between supervisors and students (Baik, Naylor, & Arkoudis, 2015). It is necessary for students to understand the importance of supervision and supervisors' work. Being honest can increase the trust of supervisors and gain their approval for the progress students have achieved such that supervisors can understand students better when students ask for help.

2. Treat the feedback correctly and have individual opinions. Although supervisors play a vital role in the success of students (Vilkinas, 2008), it does not mean everything that a supervisor says is correct. Sometimes students may have a better understanding about a task being worked on (Styles & Radloff, 2001). Therefore, it is important for them to develop their own opinions and be brave to discuss with their supervisors, which may save time and energy, and prevent misunderstanding from impeding the process (Hodza, 2007).

3. Understand the work of the supervisor and do not be over-sensitive. This is another point that students shall accept when they get along with their supervisors that supervision is only one of the jobs supervisors need to do (Barnes & Austin, 2009). As a result, it is normal when sometimes supervisors may not have time to look at students' work and give them feedback in time. Students should not be over-sensitive about it, which may lead to unnecessary suspicion, self-negation and even conflict. Patience is a crucial ability for students to develop both on their research and their interactions with supervisors (Brown, 2008).

5 Conclusion

This paper describes the experience of a PhD candidate who overcame challenges to set up his research environment and how he adapted himself to the postgraduate level of study to pass through the transition period. The findings of the candidate are outlined, with a framework proposed for students for how to handle challenges, and interact with their supervisors, based on some experiences of one of the authors in his first year of PhD study, which combines a self-directed learning concept with online learning techniques. Suggestions for students regarding how to maintain "healthy" relationships with their supervisors are also provided.

This paper does not experiment with the performance of the framework on the actual students, especially on the mental health conditions and work efficiency before and after the framework is applied, which is where the future works may focus on.

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Influence of Virtual Reality Fidelity on Oral English Learners' Learning in Different Cognitive Styles

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Abstract
Purpose – As indicated in the literature, virtual reality (VR) can provide learners of English as a Foreign Language (EFL) with scenarios close to real life in order to improve their learning. However, certain research has also shown that pursuing excessive authenticity in VR may have a negative influence on learners.
To study learners' requirements for various virtual learning environments, this research designed and developed a system based on VR with different degrees of fidelity, in order to study and evaluate how VR fidelity affects oral English learners with different cognitive styles.
Design/methodology/approach – The research adopts a pretest-posttest quasi-experimental design. Sixty-nine college students took the Group Embedded Figures Test (GEFT) to group their cognitive styles in order to determine whether they were field independent or field dependent. Then the subjects with the same initial oral English level entered different virtual fidelity environments to explore the changes in their level of oral English learning.
Findings – The experimental results showed that cognitive style and virtual environment fidelity have a significant interaction with learners' learning achievement. In the lower fidelity environment, the learning achievements of field-dependent and field-independent oral English learners did not exhibit any significant differences. However, in the higher fidelity environment, field-dependent learners had much better achievement, while field-independent learners were not influenced by the fidelity of the environment. The research results mentioned above indicate that not only fidelity but also learners' learning habits should be taken into consideration when designing VR systems.
Originality/value/implications – The findings show that the virtual learning environment can affect the learning achievement of some learners. Therefore, when designing the virtual reality learning system, we should consider the fidelity of the learning environment and the individual characteristics of the learners to provide a suitable learning environment for different learners and leading research for the construction of a virtual English learning environment in the future.

Keywords: virtual reality, oral English learning, fidelity, cognitive style, oral English training system.

1 Introduction

Nowadays, English is universally used as an international language, and the number of English learners has been increasing at a tremendous rate (Cavus & Ibrahim, 2017). In order to cope with international communication, many countries such as Japan and Singapore emphasize the importance of learning English as a second language at a young age. Among the English language skills, oral English is regarded as the most essential for language communication (Boonkit, 2010).

In the past, learners used to have limited access to English learning materials, mainly learning English from teachers' instruction in traditional English classes, and self-learning after class (Sharifian, 2017). Now, thanks to the highly advanced technologies, learners can access more learning materials, and more diversified language education methods can be created (Zhang & Zou, 2020). For instance, Hwang et al. (2016) built an internet-based multimedia system which students could use to practice oral English by making up English stories on the system platform in order to improve their oral English learning performance. Using mobile technologies to support English learning, Hwang et al. (2019) made a smart phone interface with three different subtitles, and studied how it influenced students' listening skills. Most of the existing studies show that learners will learn English more actively when they are using materials and applications (apps) on mobile devices; that is to say, English-class-related mobile apps can improve students' learning results (Zou et al., 2020). However, the traditional technology-supported English learning places more emphasis on two-dimensional words and videos which largely lack the support of three-dimensional scenarios. Due to such drawbacks as being unable to communicate in a real English social context, learners tend to focus more on their English writing skills rather than on their oral communicating skills (Reitz et al., 2019). Therefore, the lack of a real social context is one of the tough issues faced by oral English learners.

The development of virtual reality (VR) has offered a way to solve problems caused by insufficient language learning scenarios and social contexts (Chien et al., 2020) as it can simulate the physical existence in both real and imagined environments (Van Kerrebroeck et al., 2017). Furthermore, the tracking and immersion ability of VR systems can change the way of language learning (Vázquez Machado, 2018), providing learning materials which are close to what students experience in real environments (Andujar & Buchner, 2019). Elbert et al. (2016) built Ogma, a VR system, where learners become immersed in a second-language learning environment which potentially promotes second-language learning compared with traditional learning methods. Meanwhile, according to research, the more realistic the system is, the more effective the learning activities will be, while a virtual learning environment with low quality will easily trigger worse learning performance caused by the uncomfortable physical feeling (Dolgunsöz et al., 2018). However, Diaz et al. (2019) found that when learning occurs in a situation that is not highly realistic, different VR headsets' fidelity level will not cause any differences in learners' learning achievements of experiences and space learning. Therefore, studying how VR fidelity influences learning achievements is more practically significant. Meanwhile, researchers also argue that the environment will influence language learners negatively or actively (Zhang & Tian, 2019). It is therefore also necessary to study the learning environment for learners with different cognitive styles. Considering this need, this study built an oral English training system based on VR to investigate how the degree of fidelity of different scenarios would influence the learning achievements of oral English learners with different cognitive styles.

2 Literature review

2.1 Language learning supported by virtual reality

First proposed by Sutherland, the father of computer graphics (Liu et al., 2017), the basic concept of VR is that it is a kind of physical substance which recreates a real and imagined world, and is also a technology which allows learners to immerse themselves in a virtual world (Elmqaddem, 2019). VR has three features: immersion, real-time interaction, and imagination (Sun et al., 2019). These features enable learners to build a deeper connection with a virtual environment in order to have an enhanced interaction with other subjects and find their own existence as well. According to levels of immersion, VR can be classified into Desktop Virtual Reality, Cave automatic virtual environment and Headset VR. Headset VR, compared with the former two, can bring learners a higher level of immersion and promote their understanding of space. Research from Mallam et al. (2018) compared the influences of Headset VR and Desktop VR on users, and confirmed the feasibility of Headset VR for use in education and training.

During recent years, an increasing number of VR devices have been applied in the education field, especially for language-assisted learning, and some related research has also found that VR promotes language learning. Researchers have applied various VR devices or systems to study how VR technologies influence language learning. For instance, Chen and Hwang (2020) used interactive Spherical Video-based Virtual Reality (ISVVR), which provides learners with a social communicating context with a high degree of reality, to study how learners' language learning anxiety and performance in such an environment will improve their language communicating skills. Garcia et al. (2019) proposed a learning method whereby learners can learn Spanish through interactive VR by being engaged in immersive interaction games, and their data also showed that interactive VR learning is much more interesting than traditional learning. Tai et al. (2020) used a commercial VR application to study how learning via mobile-rendered head-mounted displays (HMDs) affected EFL learners' language learning. In their study, VR language learners showed higher learning and memorizing efficiencies than those who learned from traditional videos.

As indicated by a number of studies, VR technology can improve learners' language learning ability, but there are still some problems to be tackled. To date, researchers have only compared learners' learning and adapting ability when using VR technology with those using traditional learning methods in order to study the differences in learning performance. However, they have tended to ignore learning problems caused by different immersion levels of the virtual environment itself. Since learners' sense of immersion comes from the fidelity level provided by VR (Bowman & McMahan, 2007), a highly immersive environment can better improve learners' memorizing and abstract mental abilities than a low immersive environment (Ragan et al., 2010). Researchers generally study learners' sense of immersion by investigating system fidelity (McMahan et al., 2012). Fidelity refers to the imitation of the real world environment, objects and their characteristics or behavior performance, mainly including engineering fidelity and psychological fidelity (Adams et al.,2015). In virtual reality systems, fidelity refers to the similarity between the virtual and the real worlds, and includes displaying fidelity and interactive fidelity (Roger et al., 2019). Rudd et al(1996) it is believed that low fidelity usually requires an assistant who fully understands the system to complete the demonstration and testing of the system, and the user will be limited in interactivity, and that the high fidelity is completely interactive. Can be called a real product or system. At the same time, low fidelity systems often have low visual complexity, usually using simple color blocks and textures, ignoring detail elements, and high fidelity replicating real-world scenes better. Furthermore, some research has shown that VR fidelity will affect learners' learning to some extent. For instance, Warren (2018) found that high and low fidelity both affected learners in a positive way, while medium fidelity had a negative influence on learners. At the same time, individuals also differ in their acceptance of various VR systems with different levels of fidelity. Therefore, exploring how to provide suitable VR system fidelity which fits each individual is undoubtedly necessary.

2.2 How cognitive style influences English language learning

Cognitive style is the manner in which students perceive information. Herman Witkin, an American psychologist, is a pioneer in the study of cognitive styles. He, with Goodenough et al. proposed the field-cognitive mode (Witkin & Goodenough, 1981), including field dependence (FD) and field independence (FI). FD and FI refer to *how individuals focus, cognize and build their cognitive mode, and also reflects how cognitive mode is processed and memorized* (Pithers, 2002). FI learners who tend to process information by referring to themselves will not be influenced or disturbed by the outside environment so they can judge and analyze subjects independently; on the contrary, FD learners rely more on their surroundings as outside references to make judgements and analysis. FI learners, with more initiative and analyzing abilities, lack overall thinking, while FD learners can analyze comprehensively by processing information passively. Such differences in cognitive style make individuals perceive the outside environment differently, and have different results as well.

Since cognitive style is a key factor influencing students' learning results, there has been continuous exploration in the education field about how FD/FI cognitive styles influence language, especially in second language learning. At the same time, it has been gradually realized that cognitive style has a connection with English language learning, at least to some extent. For instance, Witkin et al. (1962) found that subjects with two cognitive styles had big individual differences, while also having their own merits and weaknesses. Naiman et al. (1978) found that FI learners exhibited better listening performance than FD learners in their study of Canadian students' French learning process. Nowadays, more researchers are paying attention to this aspect, and most research indicates that FI learners have more advantages in language learning. For example, Hai-yu (2017) found that FI learners had better word acquisition than FD learners. Mahvelati (2020), who studied Iranian FI and FD intermediate language learners' learning assignments of implicit second language learning, found that the FI learners could more easily focus on the materials they needed, and could memorize and retrieve information more effectively in order to improve their learning performance. Ebrahim Khodadady et al. (2016) used the test grades of mid and final English tests of 658 students registered in Imam Reza primary school to investigate the relationship between cognitive styles and English achievements. They found that the field-independent primary school students' EFL achievement was significantly better than that of their FD counterparts.

However, other researchers hold different ideas. For instance, Johnson et al. (2000) argued that FD learners perform better in second language communication in their study of how field-cognitive style influences second language communication. Therefore, there are three hypotheses about the relationship between FD and FI cognitive styles and language learning: (a) FI learners are better at second language leaning; (b) FD learners show better second language learning achievements; and (c) learners with these two cognitive styles both have strengths in second language learning. As for the latter two hypotheses, there is still much to be explored.

According to the above-mentioned discussion, researchers have made great efforts to investigate the relationship between cognitive styles and language learning, and have shown that cognitive style will influence language learning to some extent. However, only a few studies have focused on learners' cognitive styles in VR environments. Therefore, for this study, we focused on the fidelity of VR technology and learners' learning style, and we built a virtual environment oral English training system to explore the impact of cognitive style and virtual environment fidelity on oral English learners' learning. The research questions in this study are as follows: (a) How does the VR learning environment with different degrees of fidelity influence learners' oral English performance? (b) What degree of fidelity do learners with different cognitive styles require in a virtual environment?

3 Oral English training system based on virtual reality

In order to build an ideal experiment environment, this study used HTC Vive (a kind of headset VR device) and the Mindshow platform to build an oral English training system based on VR. As shown in Figure 1, the VR oral English training system includes training, learning, testing and data storage sections.

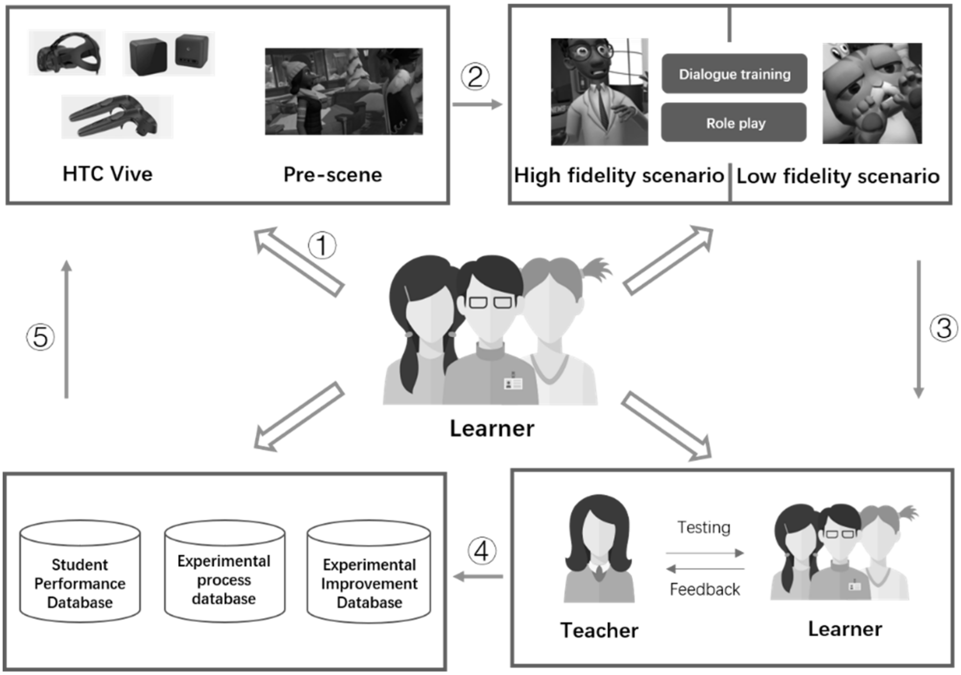

Figure 1. VR-supporting oral English training system.

Learners, except for those who suffer from 3D dizziness, could get familiar with the environment and experiment process through the training session which includes "listening & repeating" and "role play"; the virtual environment and training content are different from those of the official experiment. Then, learners formally learned oral English dialogues in the learning environment. In comparison with the training environment, the learning environment here refers to high-fidelity and low-fidelity scenarios where the scenarios and all other factors except for fidelity are identical. After finishing learning, the learners were tested in the testing environment by professional oral English teachers to assess their oral English training results.

Finally, learners' data such as learning results and learning behaviors were collected in the system's database, whose functions include data collocation, information storage and behavioral recordings. When learners had training on the system's platform, the backstage automatically collected and analyzed their data in order to create customized learning journals, process-recording audios and videos which were all uploaded into the personal account to provide better learners' self-evaluation and learners' system function.

Firstly, learners were instructed to familiarize themselves with the experimental devices and the virtual environment after being in the training environment, such as HTC Vive (the experimental devices applied here) which include the headset VR, VR base station and VR controller. They needed to use two buttons on the VR controller: touchpad and trigger. During the experiments, they could not go beyond the range of the VR base station, and needed to test whether the microphones provided were available for the characters' dubbing.

The learners were then guided to know the detailed experiment process. They firstly practiced "listening & repeating" from the third-person perspective. In the experiment, they only needed to press the Play / Stop and Reset buttons on the bottom of the left-hand control panel, as shown in Figure 2.

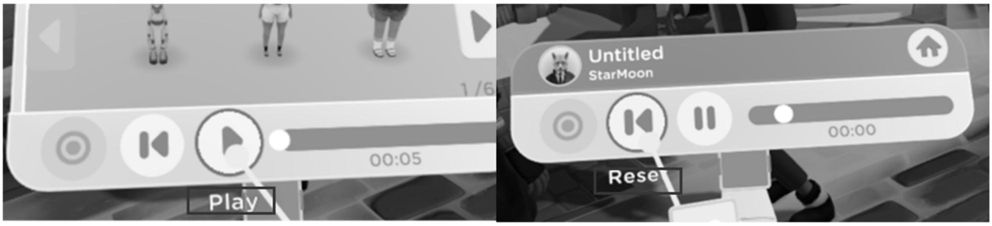

Figure 2. Training interface of "Listening & repeating"

After having finished "Listening & repeating," they could choose "role play" where they played roles according to the dialogues they had just remembered. They had to press the touchpad, hold it, move up to "Hop in" and then let it go. Next, with "right hand" aiming at the roles, they pulled the trigger. Finally, they raised their left hand and clicked REC to dub the played characters, and clicked Stop to end recording, as shown in Figure 3.

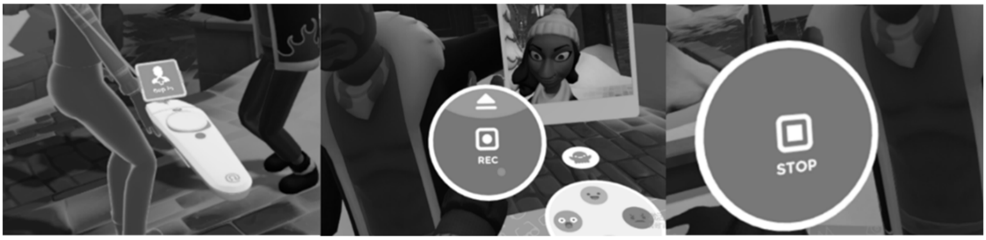

Figure 3. "Role Play" training procedures

After the training, the learners entered the learning environment, the learning process of which was the same as that of the training environment, but it was divided into high fidelity and low fidelity. In the high-fidelity environment, the participants could meet virtual characters with the appearance of humans, various facial expressions and body language. In contrast, in the low-fidelity environment, they could see non-human characters with no physical movements or facial expressions, as shown in Figure 4. The learners could control the learning process such as by pausing the dialogue for repeating, and clicking “Repeat” to restart the dialogue and listen to it again. After the training session, the learners moved into the testing session to be tested on their training results.

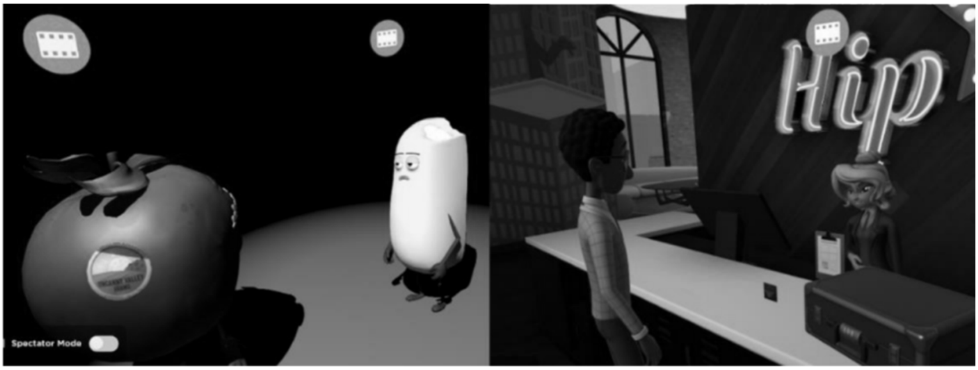

Figure 4. Virtual environment with scenarios from the two different types of fidelity.

4 Method

Aiming to improve undergraduates’ oral English level, this study developed an oral English training system based on VR, and conducted an experiment in one university in Zhejiang province. By doing so, this study tested how different levels of fidelity would influence the oral English learning achievements of learners with different cognitive styles.

4.1 Participants

This study recruited 69 non-English major undergraduates from X university in Zhejiang province to conduct an oral English training experiment in a VR environment. The grouping variables were students' cognitive style (field-dependence vs. field-independence) and virtual environment fidelity (high-fidelity vs. low-fidelity). Learner grouping is shown in Table 1. All participants were in good health and were informed about the experiment content. They could drop out of this research if they felt physically uncomfortable. None of the participants had had previous contact with VR technology, but rather were used to learning oral English through audios, videos, teachers’ instruction and self-learning. Coded according to their registration order, participants’ cognitive styles were identified as FD or FI in the pre-testing stage. Since this research developed and built two virtual environments with different degrees of fidelity, participants were firstly divided into the Odd group and the Even group according to their codes, and then received training in the system with different degrees of fidelity in order to avoid unnecessary influence caused by transition between the two. The Odd group had oral English training in the high-fidelity scenario, while the Even group received their training in the low-fidelity scenario. Finally, the research tested all participants’ oral English acquired in the whole process. It should be noted that six participants failed to complete the experiment.

Table 1
Participant Groups

Cognitive style / Virtual learning environment	Field Dependence	Field Independence
High-fidelity	18	13
Low-fidelity	15	17

4.2 Instruments

In this study, the cognitive style questionnaire was adopted from the Group Embedded Figures Test by Witkin. The questionnaire includes 18 figure tests with a full score of 18. The higher the score, the more field-independent cognitive style the subject inclines to, and vice versa. For this questionnaire, the female and male participants had 0.82 and 0.79 consistency reliability respectively (Witkin et al., 1971). After calculating the questionnaire results, this study categorized half of the participants into the field independent group and the other half into the field dependent group based on the score ranking.

In order to guarantee the scientific and rigorous nature of the spoken English in the experiment, this study selected the short-conversation listening part from TOEIC (Test of English for International Communication) to ensure that the vocabulary and grammar were suitable for the learners' English levels. The conversation was related to tourists' check-in scenarios. The post-test criteria, based on TOEIC assessments, include fluency and coherence, usage of body language, accuracy and pronunciation, each awarded 5 points. The final score was the mean value of these four criteria.

4.3 Experimental procedure

Figure 5 shows the experiment process. First, learners were coded according to their presenting order and classified cognitive styles based on their cognitive-style questionnaire. Before starting learning formally, learners were asked to familiarize themselves with the devices' operation and experiment process according to the previewing materials given by the experiment instructor. When learners entered the experiment room, they were also guided to wear the VR devices and instructed in how to complete the whole experiment by instructors.

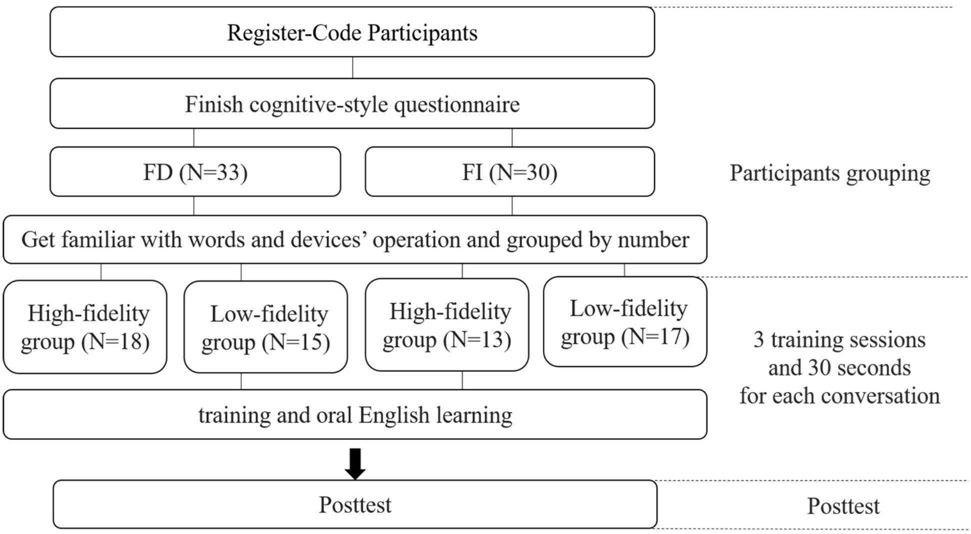

Figure 5. Experimental procedure

After practicing, the learners entered the training room according to their codes and used the VR oral English training system. The Odd and Even groups completed the oral English training assignments of "Listening & Repeating" and "Role Play" simultaneously in the two virtual scenarios with different degrees of fidelity, which was the only difference between the two scenarios. The Odd group had training and oral English learning in the high-fidelity scenario, while the Even group had the same assignments in the low-fidelity scenario. Both groups had three training sessions of 30 seconds each. After the scenario training, learners were tested on the training results in the test room by two professional English teachers. Their training results were graded according to fluency and coherence, usage of body language, accuracy and pronunciation, each of which was awarded a full score of 5 points.

5 Results and discussion

5.1 The Impact of Cognitive Style and Virtual Environmental Fidelity on the Learning Achievement of Oral English Learners

This section explores the interaction between cognitive style and virtual environment fidelity on the learning achievement of oral English learners. The whole study adopted two-way ANOVA to conduct the analysis. As shown in Table 2, the cognitive styles and scenario fidelity of the virtual environment had no clear effect on the learners' oral English learning achievements, while cognitive style * scenario fidelity had an obvious interactive effect, $F(1,59) = 5.60$, $p=.021$, $\eta^2=.085$. The interaction effect between the virtual environment's fidelity and cognitive styles is shown in Figure 6.

Table 2
Scenario-fidelity's influences on the oral English learning achievements of students with different cognitive styles

Resources	SS	df	MS	F	p	η^2
Cognitive style	0.91	1	. 0.91	1.63	.207	.027
Scenario fidelity	0.90	1	0.90	1.61	.210	.027
Cognitive style * Scenario fidelity	3.12	1	3.12	5.60	.021	.085
Errors	32.85	59	.557			
Total						

Cognitive style A	N	High fidelity B1	Low fidelity B2
		Mean (SD)	Mean (SD)
Field dependent A1	35	2.81(.58)	2.12(.89)
Field independent A2	34	2.12(.60)	2.32(.86)

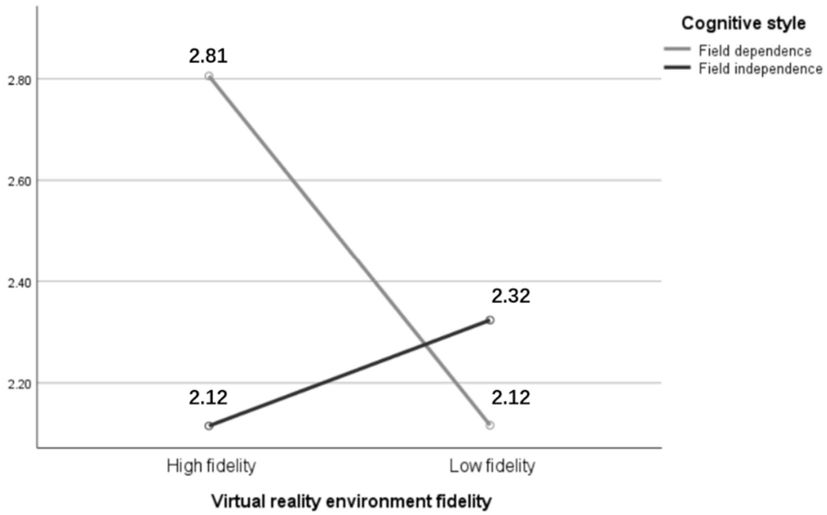

Figure 6. Interaction effects between virtual environment's fidelity and cognitive styles

The main effect results are shown in Table 3. In the high-fidelity virtual environment, learners' cognitive style had obvious main effects, F (1,59) =6.62, p=.013, η^2=.101, while in the low-fidelity virtual environment the styles did not have an obvious main effect, F (1,59) =0.57, p=.451, η^2=.010. As can be seen in the table, in the high-fidelity virtual environment, the FD learners had better oral English learning achievements (M=2.81, SD=0.59) than the FI learners in the same learning environment (M=2.12, SD=0.60). The scenarios' fidelity had obvious main effects, F (1,59) =7.05, p=.010 η^2=.107 for the FI learners but no obvious effects, F (1,59) =0.54, p=.467 η^2=.009, for the FI learners. The FD learners had much higher oral English learning achievements in the high-fidelity scenario (M=2.81, SD=0.59) than in the low-fidelity scenario (M=2.12, SD=0.89).

Table 3
Results of Main effects

Resource	SS	df	MS	F	*p*	η^2
Cognitive style (A)						
At high fidelity (B1)	3.69	1	3.69	6.62	.013	.101
At high fidelity (B2)	0.32	1	0.32	0.57	.451	.010
Scenario fidelity (B)						
at Field dependent A1	3.93	1	3.93	7.05	.010	.107
at Field dependent A2	0.30	1	0.30	0.54	.467	.009
Error	30.68	58	0.53			

According to the data analysis, in the high-fidelity virtual environment, the FD learners exhibited much better learning achievements than did the FI learners in the same learning scenario. In contrast, in the low-fidelity environment, the FD learners' average English grades were not very different from those of the FI learners. That is to say, improving the fidelity of the virtual environment can better improve FD learners' oral English achievements, but it was also shown that the fidelity level of the virtual environment had very little influence on FI learners' achievements. It is found that improving the fidelity of the virtual environment will affect some learners to some extent. According to the results data, the reason why field dependent learners are vulnerable to the influence of the virtual environment is related to their spatial understanding and knowledge transfer ability, and field dependent learners adapt to the whole learning environment more easily and quickly in the high fidelity virtual environment with rich details and clues, thus improving their learning achievement.

6 Discussion

This study created an oral English training system based on VR, and built an oral English training environment with different degrees of fidelity in order to conduct an experiment which investigated how virtual environments with different degrees of fidelity would influence the oral English learning achievements of learners with different cognitive styles. The results of this study are largely different from those of previous researchers since this study found that FD learners have much better oral English learning achievements than FI learners if they both learn in a high-fidelity virtual environment. With increasing fidelity, FD oral English learners also have much higher learning achievements. Three possible reasons for these results are suggested as follows.

Firstly, how learners with different cognitive styles understand the space may have been a reason for the final research results. FI learners are good at observing details and regarding parts as the whole in the whole environment, while FD learners are better at analyzing features of a single environment. According to some researchers (e.g., Kyritsis et al., 2009; Tascón et al., 2017), FI learners can better deal with space information and locate the key environment with higher space memory than FD learners can (Tascón et al., 2017). Meanwhile, a high-immersion or high-fidelity virtual environment will provide richer space clues to help learners better understand the space (Bowman & McMahan, 2007). Therefore, improving the fidelity of new virtual environments can enable FD learners to better understand and master the space clues in order to immerse themselves in the learning environment with higher space sense ability and learning achievements in comparison with low-fidelity virtual environments. However, since FI learners' space sense ability can hardly be influenced by the fidelity of the virtual environment, their learning achievements are not affected.

Secondly, FD learners, compared with FI learners, are more easily influenced by the environment (Lin et al., 2009). In a virtual environment, FD learners' mental pressure will be easily influenced by the visual and auditory fidelity (Zhao et al., 2017). Therefore, in a low-fidelity environment, FD learners have less mental pressure and better learning achievements as a result. On the contrary, it is nearly impossible for FI learners to be influenced by the environment, and thus their learning achievements are not affected.

Finally, the learning transferring ability of learners with different cognitive styles may also be another possible reason. It has been found by researchers that FD learners are likely to have better learning achievements than FI learners when they solve problems which are largely the same as the acquired information. Therefore, their learning achievements are not greatly influenced when they are solving problems with low similarity to what they have previously learned.

In a high-fidelity virtual environment which is largely the same as the real world, FD learners are better at observing and imitating the acquired knowledge, and have better learning achievements than FI learners. On the other hand, in low-fidelity virtual environments which are highly different from the real world, FD learners cannot internalize or rebuild the acquired knowledge as fast as FI learners can, so their learning achievements will be worse than they are in a high-fidelity environment.

6.1 Limitations and future research

There are still some shortcomings in this study. Due to the limitation of the technical conditions, the interactive function and fidelity of the oral English training system are still different from those in the real world. Although the effect of fidelity on oral English learning is studied, there is still a gap between the high fidelity virtual environment and an ideal environment. At the same time, the virtual environment with low immersion leads to the unadaptability of the learners, such as 3D vertigo, which makes them unable to complete the experiment. Future research can use more immersive VR equipment, develop more flexible virtual environment with more fidelity, increase the dimension of measurable virtual environment fidelity, and find out the most suitable degree of virtual learning environment for learners. Exploration of more possibilities for virtual learning environment design is also recommended. This study also has the problem of the small number of samples and insufficient experimental time. There is a certain dispersion of the experimental samples, which meant that it was not possible to carry out periodic experiments. At the same time, the experimental time and preparation time are short, which makes the learners practice time insufficient, and there is a certain gap between the virtual experience and imagination. The popularization of experimental results needs to be investigated. The future research can prolong the experimental cycle and expand the number of experimental samples to provide a more solid scientific basis for the adaptability and popularization of the experiment.

6.2 Implications for practice

Virtual learning environment is often effective in terms of improving students' learning achievement and understanding of abstract concepts. The research shows that virtual learning environments can improve students' interest and motivation in subject learning (Al Amri et al., 2020). Therefore, this study has some enlightening significance for the design and development of teaching environment, which is helpful for educators to understand the need to provide different virtual learning environments for learners with different learning styles, and to provide more realistic scenes for field dependents. The virtual reality learning environment closer to real life is helpful English learning. The research shows that the quality of virtual learning environment and the personality characteristics of learners are the focus of educators' attention. For example, in the process of improving the achievement of learners through virtual learning environments, learners' personal characteristics and learning habits should be paid attention to, and different quality virtual learning environments should be designed for different learners. Therefore, the construction of personalized virtual learning environments is still a problem to be solved in the future.

7 Conclusions

In conclusion, this study contributes to the literature by finding that FD learners will have better achievements in oral English learning in high- compared with low-fidelity virtual environments, while FI learners do not show any difference. According to this study, the design of VR systems should consider that the scene quality and the fidelity of the environment can affect the learning quality of some learners. Meanwhile, Environmental fidelity is not the only factor that affects learners' oral English learning achievement, it needs to provide different virtual learning environments for learners with different characteristics. How to choose a virtual environment suitable for different students is still a challenging problem. This study provides reliable advice for the design and selection of virtual learning environments in the future.

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The Effects of Virtual Reality Fidelity and Social Anxiety on Oral English Learning

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Abstract
Purpose – Studies have shown that social anxiety is an important factor in the learning process of oral English learners, and how to eliminate its influence is a matter of concern for language researchers. With the increasing application of virtual reality technology in language learning, the construction of a virtual environment suitable for language learners has attracted the attention of researchers. However, there is still a lack of research on which learning environment can improve the oral learning of students who have social anxiety. Based on the index of virtual reality fidelity, this paper discusses what kind of virtual reality environment is suitable for the oral English learning of students with different levels of social anxiety.
Design/methodology/approach – This empirical study investigates the impact of using virtual reality to support 72 non-English-major undergraduate students in China with different levels (high vs low) of social anxiety in developing oral English skills. The system used for this experiment was made from the Mindshowa platform for the design and development of an oral English virtual reality learning environment. The system consists of four subsystems: a training system, a learning system, a testing system and a data storage system.
Findings – Through experimental research, we identified the following points: in a virtual reality learning environment, learners with a high level of social anxiety can get a better academic performance; and students with low social anxiety scored higher in high virtual reality fidelity than in low virtual reality fidelity. However, students with high social anxiety can achieve a better academic performance in a virtual environment with low virtual reality fidelity.
Originality/value/implications – This research shows that virtual reality fidelity is an important indicator, which can be used in the construction of the virtual learning environment of a learning system, and a system with this indicator can adapt to students with different levels of social anxiety. Designers should design virtual reality learning scenes according to the actual situation of the learners, rather than blindly pursuing a high level of virtual reality fidelity, so as to achieve effective adaptation to learners and let them get better academic achievement.

Keywords: Virtual Reality; Social Anxiety; English Study; Academic Achievement

环境真实度与社交焦虑度对英语口语学习影响研究

摘　要：研究表明，英语口语学习者的学习过程中社交焦虑是影响学习者学习成绩的重要因素，而如何消除社交焦虑的影响是语言研究者所关注的问题。随着虚拟现实技术越来越多地应用于语言学习中，构建适合语言学习者学习的虚拟环境也引起大家的关注。但目前关于何种学习环境能够改善具有社交焦虑度学生口语学习的研究仍较为缺乏。文章从虚拟环境真实度指标入手，探讨何种虚拟现实环境适合于不同社交焦虑度学生的英语口语学习，通过实验研究得到：在虚拟现实学习环境中，高社交焦虑度的学习者能够获得更好的学习成绩；低社交焦虑的学生在高真实环境下学习成绩要高于低真实度环境；而高社交焦虑学生则在低真实度虚拟环境下会取得更好的学习效果。因此，研究认为环境的真实度可以作为虚拟学习环境建设的重要指标，用于适配不同社交焦虑度的学生。

关键词：虚拟现实；社交焦虑；英语学习；学习成绩

1 引言

在英语作为第二语言学习（ESL）的研究中，口语学习是语言学习研究的重要领域，也是技术支持的语言学习研究所关注的领域。在技术支持的语言学习研究中，如何构建一个适合于学习者自身特征的语言学习环境是近年研究的热点。随着虚拟现实技术的出现和发展，人们利用其创设大量逼真而富有情境感的语言学习环境，提供沉浸式的学习体验成为可能(Blyth C,2018)，这种沉浸式的学习环境有助于促进语言学习者有意义的学习互动和交流(Stevens V,2006)。Chen(2016)利用在线 3D VR 英语语言学习平台的研究中就发现具有沉浸感和易用性特点的虚拟学习环境对学生的语言认知有积极影响。Alfadil(2020)利用虚拟现实语言游戏屋研究虚拟现实干预对英语词汇习得过程的影响，得出了通过虚拟语言游戏屋习得词汇的学习效果要优于传统词汇习得方式。Gruber、Kaplan-Rakowski(2020）通过实验认为虚拟现实是练习公众演讲和减少演讲社交焦虑的有效工具。但是，也有学者的研究提出不一样的结论，有学者认为在虚拟现实环境中，高水平真实度的沉浸式学习环境并不总能促进学习，甚至会降低学习效果(Stevens etc,2015）。对此，一些学者提出，学习者个体差异可能会影响虚拟技术环境下的学习效果(Pollard etc, 2020)。关于哪些个体因素对语言学习会产生影响，许多学者将目光投向了学习者语言交流时产生的社交焦虑，例如 MacIntyre、Gardner (1989)发现社交焦虑是影响语言词汇习得和产生的重要因素，并强调指出基于语言环境的焦虑与语言学习密切相关。所以创建一个能够缓解具有社交焦虑学习者消极情绪的学习环境就变得至关重要，Howard、Gutworth(2020)研究了如何缓解社交焦虑对语言学习产生的影响，提出了发现和解决与负面情绪相关的压力源的方法和策略。然而，目前国内外关于构建何种合适的虚拟现实学习环境以缓解社交焦虑的研究较少，因此，本研究通过构建不同真实度的虚拟现实学习环境，探究虚拟学习环境与不同社交焦虑的语言学习者之间的相关联系，希望提出适合不同个体特征的虚拟学习环境的搭建建议。本研究主要探讨两个问题：

1. 不同社交焦虑度学习者的学习成绩在虚拟学习环境中是否存在差异。

2. 不同社交焦虑的学习者在不同真实度的虚拟学习环境中学习效果是否存在差异。

2 相关研究综述

2.1 虚拟现实技术支持的语言学习

虚拟现实技术是一种基于计算机技术，为参与者提供可交互的三维虚拟仿真环境的“沉浸式多媒体”(刘德建 etc,2016)。交互性、沉浸感和构想性是虚拟现实通过感官为参与者提供的独特体验, 也是虚拟现实支持语言学习的融合点(Bricken,1991)。虚拟现实营造的真实、轻松的交流氛围，能够激发学习者的口语表达欲望，培养学生的自主学习能力(Reitz,2019)。目前关于虚拟现实技术支持的语言学习研究主要集中在以下两个方面。

2.1.1 虚拟现实语言学习系统设计与构建

许多学者就设计与构建虚拟现实语言学习系统方面展开了研究。魏军梅(2009:57-60)针对英语口语教学存在的问题，结合虚拟现实口语教学的理论基础，从平台的设计原则、功能结构和教学流程三个方面出发提出虚拟现实口语教学平台设计方案。Hassani 等(2016)结合嵌入式教学代理，基于虚拟现实环境实现计算机辅助语言学习，整合出一个智能架构，据此搭建出一个智能虚拟语言学习环境。Ebert 等(2016)构建了包含虚拟现实学习场景和虚拟现实练习场景的语言习得系统 Ogma，并发现学习者通过虚拟现实学习系统习得的词汇保留率明显高于传统方法。也有一些学者探讨基于虚拟现实技术的语言学习模型，例如包含技术支持、理论支持、微观层面和宏观层面四个层面构建出的基于虚拟现实技术的语言生态模型(叶新东 etc,2019)，此外 Rouyer(2018)在构建 VPBLM 模型时采用以学生为中心的学习策略，关注了学生的注意力、相关性、信心和满意度等因素。这些研究为后续的研究提供了理论和实践的参考。

2.1.2 虚拟现实语言学习实证研究

一些学者通过实验，探究虚拟现实环境对语言学习的影响。Cheng 等(2017)将非虚拟现实版本的语言学习游戏与桌面虚拟现实语言学习游戏对比，证实了虚拟现实技术可以为学习者提供更为理想的沉浸感和交互体验，产生真实的存在感，更有利于语言学习的开展。Xie 等人(2019)使用移动 VR 设备（Google Cardboard 和 Google Expedition）对学生进行口语训练，发现使用 VR 工具时学习者的学习成效要显著高于不使用 VR 工具时学习成效，且使用 VR 工具有助于鼓励学习者的主动学习。Reitz 等（2019）将 EFL 学生的学习过程嵌入到三维的合作虚拟现实游戏中，通过实验发现该虚拟现实游戏能够训练学生的口语交流能力。Huang 等人（2020）通过利用基于球面视频的虚拟现实（SVVR）对学生进行教学，发现可以提高学生语言学习成绩，提升学习者创造力和自我效能感，同时降低其认知负荷。这些研究者从不角度出发，进行了基于虚拟现实技术口语学习的实证研究，通过这些研究也使更多的研究者开始重视虚拟现实技术在语言学习中的作用。

无论是理论研究还是实证研究，都为虚拟现实技术在语言学习中的应用提供了重要的经验和参考。这些研究均表明虚拟现实环境在语言学习中产生的积极作用，尤其是虚拟环境所提供的真实语境与交互，是学习者培养和锻炼语言技能

的重要体验。然而，多数研究始终重视技术对语言学习的影响结果，而轻视学习者在虚拟环境中的心理变化的影响。因此，本研究在验证不同真实度的虚拟环境对英语口语学习成绩的影响之余，将进一步加入虚拟现实环境中学习者个人因素指标（社交焦虑）。希望后续研究能够从虚拟现实环境下语言学习的过程与结果转向虚拟学习环境下学习者的个体差异，从而为构建更有效和个性化的虚拟学习环境提出建议。

2.2 社交焦虑与虚拟现实支持的语言学习

在外语学习中，具备更多自尊自信等积极的情感的学习者能创造更有利于学习的心理状态，而焦虑抑郁等消极情感则会对语言学习产生阻碍，甚至影响学习者语言学习水平的正常发挥(Amold、Brown,1999)。Oxford（1999）认为语言焦虑是影响语言学习中的主要因素，其原因有社交焦虑、测试焦虑、自尊等。而Horwits(1986)将外语焦虑分为交社交焦虑、负面评价焦虑和测试焦虑。由此可见，在语言学习的过程中，对如何缓解学生产生的焦虑情绪，尤其是社交焦虑展开研究是十分必要的。

社交焦虑是指在与人交往时，产生的不自然、紧张甚至恐惧的心理状态。Clark 和 Wells(1995)指出：“社交焦虑的核心似乎是一种强烈的愿望，即向他人传递对自己的良好印象，并对自己的这种能力产生明显的不安全感。”当一个人想要表现出良好的公共形象，但是又怀疑自己的能力时，就会出现社交焦虑（Rachman,S.etc,2000）。患有这种社交焦虑的人的典型特征是低自尊和高自我批评，会对个人的人际关系和心理状态产生不同程度的影响（Schlenker、Leary，1982）。学者们认为，语言学习与其他课程学习相比，更容易受到“社会和文化的约束”(Stein,2008)，更注重学习的情境性，从而更容易引起学生的社会焦虑。特别是对一些第二语言学习者，他们缺乏语言学习环境，无法进行真实情境下的语言交流（Chien,S.Y.etc,2020）。学者 Zhou(2016)发现，在语言学习中经历社交焦虑、特别是害怕公开演讲的学生学习自主性较差，协作学习的倾向比较弱，英语学习的成功率较低；Darmi、Albion(2012)研究发现学生的沉默、害羞、内向和社会焦虑感会影响他们的语言交流能力，这些特征会抑制他们的目标语言学习。而研究表明虚拟语言学习场景的出现，可以缓解社交焦虑人群语言交流时产生的紧张、低自尊、恐惧等心理状态(Reitz etc,2019）。结合积极心理学的理论和方法，将技术整合于语言学习中，可以引导学习者建立自信、任性等积极情绪（Drewelow,2020）。例如 Lindner 等人（2019:45-54）利用桌面虚拟现实技术创设的虚拟环境缓解学习者的演讲焦虑，实现了利用低成本的 VR 软件对 PSA（Public Speaking Anxiety，PSA）的有效治疗。Aiello、Mongibello（2019）通过利用 Oriana Palusci 团队设计并开发的虚拟软件 SpeechAce，为学习者提供可以实时练习和反馈的语音虚拟学习环境，以此改善学习者的英语发音，提升了学习者的二语自信。York 等人（2020）通过学习者在语音、视频和虚拟现实三种不同的计算机支持的语言学习环境交流模式下的反馈发现，虽然三种模式都能有效地降低学习者的社交焦虑，但虚拟现实环境是最容易交流的环境，也是最有趣和有效的语言学习环境。

从上述文献可知，社交焦虑对语言学习过程中产生的负面影响可通过在虚拟现实环境中训练学习来缓解，以此使具有社交焦虑的学习者获得更好的学习效

果。然而，目前国内外多数实验在验证虚拟环境能够缓解社交焦虑时，忽略了环境本身与学习者之间的适配性。因此，本实验希望通过构建不同真实度的虚拟现实学习环境，实现探究环境真实度与学习者社交焦虑水平的适配，以及通过实证研究获取它们内在的关系。

3 实验设计与实施

3.1 实验系统介绍

本研究的实验系统主要利用 Mindshow 平台作为英语口语虚拟现实学习环境设计和开发的工具，构建了包含训练系统、学习系统、测试系统和数据存储系统四个子系统的虚拟现实的英语学习系统。研究者可使用软件自带素材库中的资源自行搭建所需场景，并结合 HTC Vive 头戴式虚拟现实设备（包含头戴式 VR、VR 定位器和 VR 操作手柄）作为交互工具，实现在虚拟现实环境中，学生与场景中的人物发生交互并学习。（如图 1）

图 1　系统场景使用展示

训练系统包含虚拟训练环境、训练学习内容等（如图 2 所示）。英语口语学习者能够在导师的帮助下通过训练系统熟悉并适应虚拟现实学习环境，掌握虚拟现实设备的使用，并预习所要学习的单词和语句。学生经过训练系统的预适应和预学习后，可进入学习系统。

学习系统中的英语口语学习场景分为低真实度和高真实度场景，低真实度场景中的交互角色为非人类卡通形象，而高真实度场景中的交互角色则以人类形象出现，并能做出丰富的面部表情和肢体语言。学生可自主选择自己所喜爱、需求的学习场景，扮演场景中的人物完成口语对话，进行虚拟环境下的沉浸式学习。目前学习系统的对话材料内容选自 TOEIC 真题，包含英语母语环境日常所需的对话内容，所涉及的单词及语法均在学习者认知水平之内。

测试系统主要在学习者完成学习内容后提供虚拟环境测试场景，并收集统计学习者相关数据(英语口语学习成绩、学习者焦虑度、学习者认知负荷水平等)，为数据存储系统中的数据分析提供数据来源。

数据存储系统主要功能为收集和存储测试系统反馈的学习者数据，并选择相关算法分析数据内容，根据数据分析情况改进系统，例如学习内容、场景布置

等要素，教师可根据学习者数据分析反馈选择适合不同风格学生的教学方法和策略。

图 2　基于虚拟现实的英语学习系统

3.2 研究对象

本实验的研究对象为 72 名来自 XX 大学非英语专业的在读本科生，研究对象之间初始英语水平基本相同，并对 VR 技术感兴趣，且在训练、学习及数据搜集过程中，如有学生感到身体不适或拒绝实验继续进行时，现场工作人员将依其意愿随时停止实验进程。所有学生在进行口语训练前将进行社交焦虑度问卷测试，根据问卷得分区分为低社交焦虑与高社交焦虑两组。分别依次进入不同真实度的房间。测验开始前，所有学生会先熟悉实验所涉及的基础词汇和基础环境。训练结束后，所有学生将进行场景会话内容后测，并对此进行统计分析。

3.3 测试工具

本实验所用到的测试工具包含：虚拟现实设备 HTC Vive、LSAS 社交焦虑量表、TOEIC 听力真题、后测评分标准。虚拟现实设备包含头戴式 VR、VR 定位器和 VR 操作手柄，用以呈现虚拟场景、实现人机交互、收集学习者行为和录音。LSAS 社交焦虑量表是 1987 年由心理学家 Liebowitz MR.编制用来评价社交焦虑障碍评估的广泛使用的工具。实验中以社交焦虑量表总分 40 为分界值，共有 24 个问题，每个问题又分为害怕和回避两个分量，采用 0-3 的 4 级评分法，总分在 0-144 分，其中包含社会交往因子等四个因子。实验中所有用以练习和测试的英语对话材料均来自 TOEIC 英语能力测评考试试题，主要针对学习使用英语交流的人们，用于测试非英语母语人员在国际性环境中使用英语的能力。

3.4 实验流程

实验流程如图 3 所示，参与者到达实验场地后进行签到和编号，并进行社交焦虑度水平测试，根据测试结果将参与者分为低社交焦虑度水平和高社交焦虑度水平两组，进入虚拟现实训练学习场景，由工作人员对其进行实验设备的操作展示和练习指导，并熟悉训练对话中可能出现的相关词汇。结束训练环节后，所

有参与者将进入虚拟现实英语口语学习场景中进行学习，学习过程经历低真实度场景和高真实度场景两部分。在学习过程中，参与者将经历 6 次的口语练习，练习将在低真实度场景与高真实度场景下各进行三次，包括听读对话和角色扮演，每次时长为 30 秒。结束学习后，参与者将进入测试系统进行自由角色扮演环节，即还原角色的对话内容，进行实验后测。实验后测中，参与者口语对话表现音像将被收集，并送由两名英语专业的老师对此录像进行分析，对参与者的口语水平、内容还原、语言流利度和连贯性、肢体语言丰富度、准确性和发音等综合方面进行考核，且按照评分标准对其学习成绩进行打分。

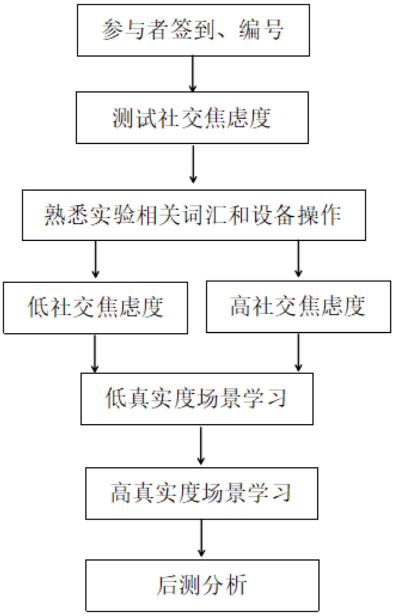

图 3　实验流程图

4 实验结果与分析

对本次实验中搜收集的各项数据结果进行分析与讨论后，结果分为以下两个部分：第一部分，对经过虚拟现实环境训练后，不同社交焦虑度的语言学习者学习成绩的差异分析；第二部分，是以学习成就作为因变量、以社交焦虑度、虚拟现实场景真实度作为影响因子对其进行方差分析。

4.1 社交焦虑度对学习成绩的影响分析

以独立样本 T 检验分析发现，不同社交焦虑度的语言学习者经历了虚拟现实口语环境训练后，学习成绩有显著差异。表 1 给出了不同社交焦虑度的学生后测成绩的描述性统计量和检验结果，低社交焦虑组学习者的后测成绩与高社交焦虑组学习者的后测成绩相比有显著差异（$t=-2.55, P=0.013<0.05, d=-0.61$），低社交焦虑组学习者的后测成绩平均值（$M=2.46, SD=0.83$）要低于高社交焦虑组学习者的后测成绩平均值（$M=2.90, SD=0.59$）。也就是说，在虚拟现实英语口语训练环境

中进行训练及学习后，相较于低社交焦虑度的英语口语学习者，高社交焦虑度的英语口语学习者能够获得更好的学习成绩。

表 1　社交焦虑度与学习成绩检验结果

社交焦虑度与学习成绩检验结果							
	社交焦虑	N	Mean	SD	t	p	d
后测得分	低社交焦虑	34	2.46	0.83	-2.55	0.013*	-0.61
	高社交焦虑	35	2.90	0.59			

注：*P≤0.05。

4.2 社交焦虑、虚拟现实环境真实度与学习成绩的关系分析

表 2 和图 3 显示了将后测学习成绩作为为因变量，学生不同的社交焦虑度和虚拟现实口语训练环境的不同真实度作为影响因子构成的单因变量多因素方差分析结果。根据方差分析结果来看，可以得出学生的英语口语学习会受到社交焦虑和虚拟现实环境真实度的影响（F=3.315，P=0.025<0.05），社交焦虑对学习者的学习成绩有显著影响（P=0.009<0.01）。

表 2　方差分析结果表

因变量:后测得分	df	MS	F	p
修正模型	3	1.697	3.315	0.025*
社交焦虑	1	3.720	7.268	0.009*
真实度高低	1	0.480	0.938	0.336

注：*P≤0.05。

根据轮廓图我们可以看出，经过虚拟现实口语环境学习，高社交焦虑度的学生的成绩要高于低社交焦虑度的学生，低社交焦虑度的学生在高真实度的虚拟现实口语学习环境下能取得更好的学习成绩，而高社交焦虑度的学生能够在低真实度的虚拟现实口语学习环境下获得更好的的学习成绩。

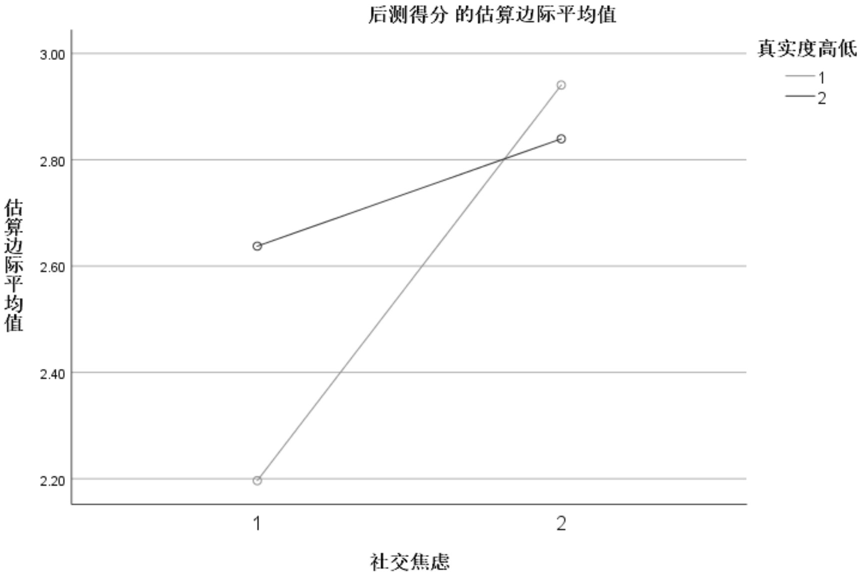

图 3　不同社交焦虑和虚拟环境真实度的估算平均后测得分轮廓图

5 研究结论与展望

随着技术的发展，已有学者研究证明了 VR 能够有效减少学生的口语学习焦虑感(Hinojo-Lucena etc,2020)，Price 等人(2011)的研究首次通过实证研究探讨沉浸感作为虚拟现实技术治疗社交焦虑的机制，同时，邹敏(2019)发现，VR 场景化学习能降低学生在对话场景中的外语口语焦虑,且这一降低效果对于原本英语焦虑度高的学生更加明显，这与本实验的结论一致。而与之前研究有所区别是，本实验通过研究发现，（1）语言学习过程中，高社交焦虑的学生更适合虚拟现实环境中的口语学习，能够更有效地帮助其提高口语学习成绩。因此可以通过为具有高社交焦虑的学习者提供虚拟学习环境，帮助提高口语学习成绩；（2）研究发现高社交焦虑的学生在低真实度的环境中的学习效果更好，因此虚拟学习环境应与学习者相适配，并非盲目追求高真实度的学习环境建设。

研究结果表明，高社交焦虑度的学习者与低社会焦虑度的学习者在经过虚拟环境学习训练后学习成效有显著差异，相比之下，高社交焦虑度的学习者口语学习成绩更高。这项研究结果表明，虚拟学习环境更有助于促进高社交焦虑者的学习。这种结果或许可以用叶克斯-多德森定律解释，即激奋水平和学习成绩之间存在倒 U 型关系，适度的压力水平能够促进学习成绩的提升，压力水平过大或过小则会影响学习者的学习效率和学习成绩(Yerkes R M、Dodson J D,1908）。社交焦虑程度较高的学习者在虚拟现实环境中的压力水平同社交焦虑程度较低的学习者相比，或许更接近于适宜学习的压力数值水平。因此，在今后的英语口语教学中可考虑引入虚拟现实技术，为具有社交焦虑的学习者提供适宜其学习的口语学习环境。

而现今对虚拟环境的研究不断增多，如何设计合适的虚拟环境促进学习者学习越来越重要。目前人们普遍认为，高真实度环境带来的沉浸感能够提高学习者在模拟环境中的学习效率（Cummings J J、Bailenson J N,2016）。但本研究发现，相较于高真实度场景，高社交焦虑度者在低真实度场景下的学习成绩更高。这或许与恐怖谷理论有关，日本学者家森政藤绘制出人类对类人物品感觉变化倒 u 形曲线，指出当仿真人与人类相似度达到一定程度时，人类对其好感度会降低，甚至会加剧人类焦虑不安等情绪（Mori M etc,2012），而 McMahan 等人（2016）则在实验中发现与恐怖谷理论相似的学习者认知 u 形曲线，图线表明，学习者在低沉浸感和高沉浸感的虚拟现实环境中，认知水平比中沉浸感程度的虚拟现实环境更好，结合这两点分析，高社交焦虑度水平的学习者在学习和生活中面对真人会有心理不安感，而在低真实度场景的虚拟环境中，非人类形象的人物，例如卡通类虚拟形象，能够减少学习者紧张不安的情绪，使学习过程更加轻松，但真实度的提升会重新带给高社交焦虑学习者恐惧、不安等情绪。因此，社交焦虑度较高的语言学习者可选择在适配其认知水平曲线适宜区段的学习场景中进行训练学习，提高学习成绩。由此可知，设计者应根据学习者实际情况设计学习场景，而非盲目追寻虚拟现实学习场景的真实度，以此达到与学习者之间的有效适配，从而产生更好的学习效果。

然而本研究仍存在一些缺陷和不足，从实验周期来看，实验开展的学习周期时间较短，并在实验结束后未能对学习者学习效果进行长期追踪研究；从实验样本上来看，本实验样本量偏少，且研究主体单一，而本实验未来期望能将研究扩大到中小学生，进而推广实验所得结论，解决更多学段英语口语学习者在习得口语时所遇到的社交焦虑问题。此外，接下来的研究计划将开展多样化样本，周期更长的迭代实验研究，结合眼动实验等生理参数，优化升级数据存储系统，改进数据分析算法，将其结合人工智能导师分析的学生反馈数据，量化真实度指标，指导学习者学习并优化系统内容，从而完善此虚拟现实英语口语学习系统，实现环境与学生的智能适配，探索虚拟现实环境在学习上的深层影响。

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Design and Realization of Virtual Simulation Experiments in Engineering Distance Education

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Abstract
Purpose – Underlying new engineering, practical teaching is the focus and difficulty of quality assurance in distance education. Distance education has developed rapidly in recent years in China, but practical teaching is not satisfactory. How to effectively solve these problems and construct a distance education practice course teaching model suitable for training new engineering talent is a topic that must be studied and considered.
Design – This study analyses the problems of practice teaching in distance education and the roles of virtual simulation experiments in practice teaching. It develops a virtual simulation practice platform based on project modularity to apply to the practice teaching process.
Findings – Lack of personal experience in actual training venues is not conducive to the formation of students' safety awareness. Through the student data of the operation of the virtual simulation experiment, we know the construction of the virtual simulation experiment breaks the traditional form of face-to-face education, breaks time and space boundaries between teachers and students, and provides a new multidimensional mixed teaching mode for practice teaching. Students can not only acquire theoretical knowledge but also simulate practical training in the learning process. This is conducive to cultivating the innovative consciousness and practical ability of students.
Value – This study is a useful exploration to improve the teaching of engineering in distance education.

Keywords: practice teaching; distance education; new engineering; virtual simulation

1 Introduction

The new round of scientific and technological revolution and industrial transformation calls for new engineering. The new engineering requires quality education, strong subject foundation, cross-professional knowledge, and new teaching methods as their characteristics. It also emphasizes practical teaching and innovative thinking. The new engineering professional settings requires to connect with the frontiers of disciplines and meet the needs of industries[1-3].As the main force of distance open education in China, the goal of talent training is to cultivate application-oriented talents, and the main group front-line employees. Engineering, as an important part of distance education, is in urgent need of innovation and practical teaching reform. Engineering teaching has always been recognized as a difficult point in the development of distance education, and how to develop practical teaching in engineering distance education is one of the difficulties. Practical teaching is an important guarantee for the cultivation professional comprehensive application ability and practical innovation ability of students, and an important indicator of distance education teaching evaluation. Therefore, how to carry out practical teaching and how to reform and innovate practical teaching content, teaching mode in modern distance education have become an urgent problem to be solved at present [4,5] .We should explore ways and methods to solve practical teaching in distance education.

2 Problems Existing in Practice Teaching of Engineering Courses in Distance Education

Practical teaching refers to the construction of educational, creative, practical, and operational activities as the main form in the teaching process, with the basic characteristics of encouraging students to actively participate, actively explore, actively think, and actively practice. The practice teaching focuses on the cultivation of students' skills and the comprehensive development of various abilities, and promotes the improvement of students' overall quality. Practical teaching and theoretical teaching are closely linked, they are an important factor in achieving the goal of talent training and indispensable. Especially for engineering students in distance education, the mastery of theoretical knowledge should not be limited to simple memory, but should focus on the connection between theory and practice. It is necessary to strengthen the ability to flexibly use theoretical knowledge to solve problems in practice, so as to realize the cultivation of practical ability and the seamless connection of positions [6, 7].However, the engineering practice teaching is still a relatively weak link in open distance education at present. Practical teaching has not played its due role in cultivating professional skills of students. The importance of practical teaching is not well understood.

The shortcomings of practical teaching in engineering distance education are mainly reflected in the following aspects:

1. Due to practical teaching need highly expensive facilities and equipment, laboratories and practice bases are relatively weak and cannot meet the needs of teaching in the case of limited funds.

2. The implementation of the practical teaching is not very planned, lacks active thinking and targeted measures. The practical teaching mode is relatively single, and it fails to effectively use social resources.
3. The foundation and abilities of students vary greatly, but the teaching plan for the practical link is too unified.
4. The practical teaching resources provided are too few, the form is single, and the innovation is lacking.
Therefore, it cannot adapt to the learning particularity of engineering distance education students only relying on traditional experimental equipment and class mode.

3 The necessity of developing virtual simulation experiments in the distance education

In 2020, the coronavirus swept all over the world. The Ministry of Education issued a document requesting the full play of the role of "Internet + Education". It proposed that the national virtual simulation experiment sharing platform provides free virtual simulation experiment course resources, and provides online experimental teaching support and teaching assessment management, etc. These can ensure that various practice teaching and experimental courses "non-stop" during the epidemic. The Open University of China implements the requirements of the Ministry of Education to “suspend classes without suspension”, they make full use of “cloud classrooms”, open multiple learning platforms and multiple resources for free, provide students with diversified teaching services, and ensure that teaching work is orderly in special periods (Degang Jing, 2020).
In addition, the characteristics of adult continuing education and self-study-based learning mode determine that experimental and practical links are different from the traditional offline education mode. Due to the constraints of cost, time, space and other factors, students lack sufficient experiments and practical training in the process of distance learning[8]. Therefore, exploring a new practical teaching model suitable for distance education and insisting on technologically supporting innovative school running have become a problem that must be faced in improving the quality of education(Yu Lin, 2020). With the continuous development of modern information technology and the progress of teaching application realization methods, computer simulation technology, network virtual experiment, VR technology-based micro-courses, voice recognition technology-based online courses, etc., these bring new realization methods and innovation opportunities to the practical learning in the distance education.
After more than ten years of construction and development, the automobile major in the Open University of China has cultivated a large number of urgently needed talents for the society and industry, and has been widely recognized by the society. However, due to the limited practical teaching conditions in the teaching process, there are still many deficiencies in the practical knowledge application and hands-on ability about students. Take the engine disassembly and assembly technology in the automobile profession as an example. Engine technology is constantly updated, and advanced engines continue to emerge. The engines provided by schools are relatively backward and old. Students can only learn more about advanced engines through multimedia, and cannot actually touch them, which leads to low learning interest and enthusiasm

of students. On the other hand, the training equipment is expensive, and it is difficult to upgrade. We use simulation technology to design and develop virtual simulation experiments, and use computers to simulate real scenes with 3D effects, so that students can get an intuitive experience in a virtual environment. This can not only effectively save manpower, material resources and financial resources, but also cultivate high-quality technical personnel at the lowest cost. The virtual simulation experiment is conducive to cultivate learning interest and improve creativity of students, and thereby it can improve the quality of teaching.

4 Application of CDIO Concept and Project Teaching Mode in Virtual Experiment

The CDIO engineering education model is the latest achievement of international engineering education reforms in recent years. CDIO stands for Conceive, Design, Implement and Operate. It takes the life cycle from product development to product operation as the carrier. Let students learn engineering in an active, practical, and organic way between courses. This kind of education mode carries out classroom teaching with actual engineering project cases, and cultivates technical knowledge and reasoning ability, personal professional skills and professional ethics, interpersonal team ability and engineering system ability of students in the implementation of the teaching process.

The project-based teaching model is based on absorbing modular thinking methods, it decomposes the knowledge of the course into individual knowledge points, and then combines the knowledge points into relatively independent knowledge units. According to the professional ability needs by different professional post groups or technical fields, it combines related knowledge units into teaching projects, and realizes the update and adjustment of teaching content by adding and deleting units and adjusting the combination method.

The project-based teaching model has the following characteristics:

1. It needs determine the content firstly and then determine the project based on the training objectives.
2. Each project is relatively independent, and it can obtain a skill, knowledge or ability after each project completed.
3. Projects can compose flexibly, each project combination has clear behavioral goals and specific requirements.
4. Projects are highly efficient and expandable, and can reflect the new technologies, new methods, new techniques generated by the development of the industry.
5. Project-based teaching starts with the analysis of the job vocational ability. it determines the corresponding professional operation skills. Then, it conducts teaching analysis and teaching design to form the corresponding project teaching module according to the needs of the job skills.

Based on the CDIO concept and project-based teaching theory, we have developed a virtual simulation experiment for automobile engine disassembly and assembly. We designed teaching activities in accordance with the integration of rationality and reality, and Practice was interspersed in the theoretical teaching. Through virtual simulation experiments, students can achieve the purpose of consolidating basic theoretical knowledge, training basic skills, mastering basic operating methods. In addition, virtual simulation experiments can cultivate adaptability and innovative consciousness of students.

5 Application of Virtual Simulation Technology in Practice Teaching of Automobile Specialty

5.1 Development and Design of virtual Simulation Experiment for Engine Disassembly and Assembly

The virtual simulation experiments that we developed and designed are based on 3D scenes and 3D virtual equipment, including engine disassembly and assembly, chassis disassembly and assembly, and car assembly. There are workshops, safety regulations, workbenches, tools, etc. The structure of parts that are invisible to the naked eye is clearly visualized, giving people an immersive feeling. Take the engine disassembly and assembly project as an example. The disassembly and assembly technology of automobile engines is complicated, and it requires the use of knowledge in physics, mechanics, structure, etc., combined with the specific model of the car, to simulate and practice the components and the whole. This project requires students to be proficient in the disassembly and assembly of major engine institutions, which is the basis to engage in basic skills in automobile maintenance for students.

First, by showing the 3D video of engine disassembly and assembly, let students understand how virtual simulation technology is used in the process of engine disassembly and assembly. Then the teacher assists students to master the basic theories, familiarize the basic operating procedures, guides the students to learn and practice progressively, and carry out simulation training teaching. After the students have a certain basic knowledge, they start virtual simulation training. This link can not only detect the students' mastery of knowledge, but also exercise the learners' hands-on operation ability and the think problems ability from multiple angles. After the simulation experiment is completed, students can deepen the impression and consolidate the knowledge through after-school exercises. The engine disassembly experiment includes the following parts:

1. Simulation of engine disassembly

This part of the work is mainly to enable students to have a deep understanding of the internal composition of the engine. With the help of virtual simulation technology, they can clearly grasp the location of each component, select the correct tools according to the prompts of the simulation software, and proceed according to the specifications. As shown in Figure 1 and Figure 2.

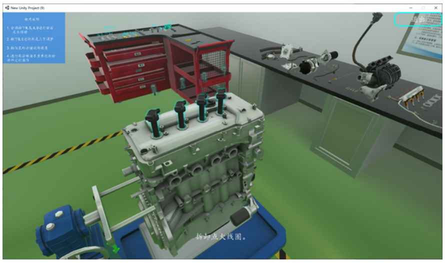

Fig. 1. Engine disassemble

Fig. 2. Engine removal tool selection

2. Parts inspection simulation

Compared with manual technology, virtual simulation technology can clearly present basic information such as the size and performance of each part. Maintenance personnel can quickly determine whether the parts are qualified and required for repairs. At the same time, it also solves the loss of parts and greatly improves the efficiency of engine maintenance.

3. Engine assembly simulation

Engine assembly work is also an extremely complicated task in actual maintenance. The introduction of virtual simulation technology can clearly show the assembly position of each engine component. Through the 3D display, the entire assembly process can be displayed in an all-round way without dead corners, thereby guiding students to assemble according to the instructions of simulation software, as shown in Figure 3.

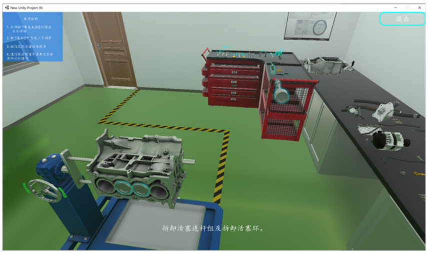

Fig. 3. Engine assembly

4. Establish a database for engine disassembly and assembly

As a management material, the establishment of related databases ensures the smooth formation of the entire virtual environment and the benign communication among students. The establishment of its network mode and stand-alone database is completed by strict database technology [9]. The database includes disassembly method information, disassembly position information, feedback value information, feedback condition information, technical information, document information, step information, torque information, tool information, component information, engine information, etc.

5. Compile management and assessment procedures

After completing the above work, the overall management of the virtual engine disassembly and assembly and the evaluation program are programmed to conform to the actual situation. This operation is mainly to record the core process of the simulation project. Including the development of specific assessment content, the coordinated use of related databases, the control of the overall virtual environment, the control of 3D information files, etc., a complete virtual simulation technology system is finally formed to guide the development of follow-up work.

After the training simulation is completed, the next step is to enter the actual combat drill and complete the homework. In this process, it is necessary to test the results of the students' learning virtual simulation technology for engine disassembly and assembly. Let the students conduct timing competitions, repeatedly operate the simulation software for timing training. This can stimulate the motivation of learning through timing training. At the same time, students can master the skills of engine disassembly and assembly more proficiently. This process is shown in Figure 4 and Figure 5.

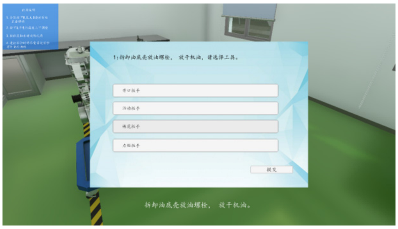

Fig. 4. Engine disassembly and assembly

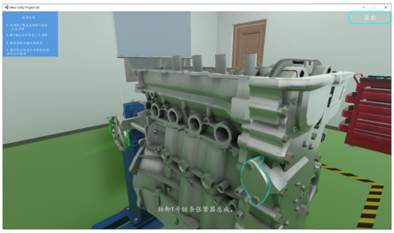

Fig. 5. Engine timing drill

5.2 Evaluation and consolidation

The learning process is a dynamic process. Therefore, after learning, the learning achievements should be evaluated and consolidated in time to deepen the impression. As the saying goes: "Seeing a thousand times is not as good as passing it by hand." Although virtual simulation technology can clearly find out the problem and guide the smooth operation of the operation process, it still needs to do hands-on training and consolidate the learning results in time. At the same time, it is necessary to sum up experience, strengthen students' norms and safety awareness during practical training, and consolidate teaching content. So far, the basic process of virtual simulation training for automobile engine disassembly and assembly has been completed. This process is a dynamic development process, which not only involves preliminary preparation and simulation operation, but also pays attention to the feedback of later teaching evaluation.

5.3 Project reflection

Using virtual simulation technology to carry out engine disassembly and assembly training has brought great convenience to automobile engine maintenance, but there are still some problems, as follows:

1. The lack of personal experience of actual training venues is not conducive to the formation of students' safety awareness. The use of simulation software is relatively casual and will not cause personal injury to students. This also brings great disadvantages. Students will develop the operating habit of simulating teaching scenes. They are not very vigilant about safety in actual operations. It's easy to cause safety accidents.
2. The operation process is too stylized and can't cultivate students' on-the-spot adaptability well. The simulation software is pre-designed by computer programs, so the operation mode is fixed. But there will be many emergencies in the actual operation site. The use of tools and methods should not be rigid, and must have a certain ability to adapt to changes.
In view of the main problems existing in the use of virtual simulation experiments, the following two improvement measures are proposed:
1. With the development of virtual simulation technology, the capacity of simulation database should be continuously increased to enhance the effect of virtual simulation. Due to the limitations of computer hardware and software, the running speed of the car simulation software is not high and the vehicle model is relatively single. We should continue to optimize the database and develop simulation programs for more car models.
2. Virtual simulation teaching can be a useful supplement to physical teaching, but it cannot completely replace physical teaching. Joining the physical practice teaching before the virtual simulation teaching, the two methods can complement each other and promote each other.

5.4 Application effect of virtual practice platform

Table 1 Basic data on the operation of some schools

Divisions	Total number of students	Sum of actions	Number of resources browsed by students	Number of student forum posts	Number of teacher replies
Jiangsu	735	90480	62454	909	3183
Xi'an	576	58410	41685	597	564
Sichuan	169	8493	7017	157	121
Anhui	642	50679	40011	594	348
Hunan	354	23301	16155	3	54
Henan	174	5478	4047	0	0
Hebei	663	50436	40599	114	120

In the fall of 2020, 38 schools have selected courses on the Learning Network in the Open University of China. The number of students who log in to the virtual simulation experiment is 2,507. The data shows that the number of student resource browsing behaviors is 181,830, 72.5 per capita, and the student's learning behavior is relatively active. It can be seen from Table 1 that students' online learning behaviors are active and often. This new practical teaching model is more popular for students, and the overall response of students is good. The system has solved the problems of the lack of network laboratories and the difficulty in practical teaching at the grassroots teaching sites.

The advantages of the virtual simulation experiment of automobile engine disassembly and assembly are as follows:

1. Improve the effect of practical teaching

Through the three-dimensional virtual scene, learners can operate different experimental equipment and learn in the process of interaction with the experimental equipment. Knowledge becomes intuitive and vivid, which can avoid the boring feeling that is easy to appear in the learning process. Learners find the answers themselves by doing, communicating, reflecting, and exploring in the virtual environment, which is more conducive to the construction of knowledge; through the interaction in the virtual environment, it also promotes the understanding of knowledge. Throughout the process of practical exercises, students will gain new teaching content and enhance their comprehension and memory abilities [10,11].

2. Improve the safety of practical teaching

The application of simulation software has a certain degree of safety compared with the traditional physical operation form. The simulation training designed by the simulation software can allow students to perform actual operations. This can eliminate possible safety hazards and will not threaten the lives and health of students.

3. Favorable supplement of teaching resources

With the implementation of the teaching reform, the traditional teaching concepts have changed. Virtual simulation technology can display the internal structure of the car in a dynamic and three-dimensional form, including parts, vehicle parts and total parts. Through the three-dimensional display, maintenance personnel can more intuitively understand the assembly and disassembly of the car, the location and assembly of parts, and so on. The school can train high-tech talents adapting to social development in the shortest time with a lower cost. At the same time, it can also solve the shortage of teachers in some schools, save a lot of space for schools, shorten the training time of students, and reduce the investment in teaching funds [12,13].

6 Summary

The application of virtual simulation technology can solve many problems in traditional engine disassembly and assembly training. Students can conduct engine disassembly and assembly training on the virtual simulation platform at any place and at any time, and repeat operations in accordance with the requirements of the specification. It helps students to master engine-related knowledge. On the other hand, it can reduce the investment in venues, equipment and related personnel, save costs, and improve the safety of training. At the same time, this advanced technology can stimulate students' interest in learning, mobilize students' enthusiasm, deepen students' memory of knowledge, and achieve the goal of final training. This kind of training mode meets the learning behavior of the students in the Open University of China. It can strengthen the cultivation practical ability, and deepen the mastery of theoretical and practical knowledge of students. It is a useful exploration to improve the teaching effect of engineering practice.

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