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博士生論壇論文集

Doctoral Student Forum Proceedings

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一. 序言 Message from the Organiser

GCCCE 2021 博士生論壇為支援計算機教育應用領域中年輕研究人才的成長，向全球華人優秀博士生提供一個與同行交流學術的平台，並在和他們研究領域相關的專家小組的引領下深入討論問題。參與者就他們的博士論文進行協作探究以及學術討論，從而對研究進行完善，改進以及深化對電腦教育的理解。本論壇為參與者提供了一個機會去思考他們博士論文研究和提出值得進一步調查和討論的問題；一個與專家小組和其他博士生對話的平台，參與者可以貢獻想法並且接收對他們當前的研究的回饋意見和指導；一個共同體來支援活躍在計算機教育研究領域的年輕學者。

本論文集收錄了 5 篇由參與者撰寫的論文，涵蓋了 GCCCE 2021 其中多個主題。今年的博士生論壇包含三個部分：短演講、報告與討論，以及一對一私人指導會議。前兩個部份會開放給所有 GCCCE 的與會者，但是第三部分則僅限博士生論壇主席、邀請專家以及博士生論壇論文被接受的學生作者參與。在短演講的部分，今年博士生論壇有榮幸邀請到 2020 IEEE TCLT Early Career Researcher Award 得主 Dr. Ahmed Tlili 針對 "Planning for your research career while working on a doctoral degree" 與博士生們分享他的經驗和建議. 在報告與討論和一對一私人指導會議，博士生論壇也得到以下專家小組的全力協助:

Chien Sing LEE, Sunway University 雙威大學
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我們必須再一次感謝 28 位來自中國內地、台灣、香港和新加坡的資深華人學者擔任程序委員。

張明治 阿薩巴斯卡大學（加拿大）
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The development of reading skills in concept mapped pre-reading activities via *Xiaohuazhuo*: does the group size matter?

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Abstract: *Reading offers language development opportunities and reading ability impacts learners' academic achievements. Previous studies supported the value of collaborative reading in developing individual reading ability. In the current digital era, the effectiveness of digital-enhanced collaborative reading (DECR) in assisting reading comprehension is recognized. However, a paucity of studies considered the pre-reading activities and the effects of group size. The current study addresses these by examining whether learners in small groups of two, three, four, and five differ in reading skills (i.e., overall reading performance, skimming, and scanning), concept map performance, collective efficacy, and satisfaction in the Xiaohuazhuo-based group concept mapped pre-reading (XGCMP) activity. A pre-and post-test design will be conducted among 97 EFL Chinese learners in a junior college. Reading skills are evaluated by reading comprehension tasks. The within- and between-group differences of reading skills are compared through paired t tests and a one-way MANOVA. The comparison of concept map scores across groups is subjected to a one-way ANOVA. Learners' responses to the questionnaires of collective efficacy and satisfaction in the post-test are analyzed by one-way ANOVAs to examine the differences across groups. The results may indicate the importance of pre-reading activities and remind teachers to consider group size when they arrange group activities.*

Keywords: Pre-reading activity; Group size; *Xiaohuazhuo*; Digital-based collaborative reading

1. Introduction

In language learning, reading provides opportunities for language development (Lan, Sung, & Chang, 2009). As reading ability is a complicated skill in language development, which impacts learners' academic achievements (Lan et al., 2009), researchers have sought ways to develop it. Collaborative reading is such an approach due to the peer scaffolding and interaction that it poses on learners (Su & Zou, 2020), which refers to members jointly construct meaning and knowledge of the reading contents through text-based discussions (Chen & Chen, 2014).

Recently, the advent of digital tools to collaborate with others facilitates the field of digital-enhanced collaborative reading (hereafter, DECR) (Lee, 2015). However, DECR does not always produce satisfactory reading outcomes for learners (Lee, 2015). Strategies are needed to assist this situation. A plausible way is to draw concept maps, which is effective in organizing and representing knowledge (Novak & Cañas, 2006). Concept mapped pre-reading strategy could help learners convert linear textual contents into a nonlinear graphic presentation, thereby leading to their in-depth understanding of the reading material (Andoko, Hayashi, Hirashima, & Asri, 2020). The present study bases concept mapped pre-reading activity on *Xiaohuazhuo* to support English as foreign language (EFL) learners. *Xiaohuazhuo* is an online platform (https://xiaohuazhuo.com/) to support learners' collaborative reading and concept mapping. Learner groups can paste the reading contents to the group webpage in *Xiaohuazhuo*. Each member can leave notes and post questions in the blanks after individual reading. Other members can answer questions and discuss around the uncertainties. After that, groups can draw maps for the reading contents in the same group webpage. Learners can draw with the paintbrush and different types of graphs such as box and circle, and arrows, annotate the drawing with texts and notes, and mark the drawings with different colors. *Xiaohuazhuo* supports synchronous and asynchronous team drawing, where participants could collaboratively draw concept maps for the reading texts, and they can edit (a)synchronously, view or revert to previous version, and monitor groupmates' participations while mapping themselves, even without technical knowledge. Moreover, *Xiaohuazhuo* is convenient for revision as it supports the deletion of any content without stain, and the revision history appears important for learners' reflections on the contents that the group have drew.

2. Literature review

2.1. Digital-enhanced Collaborative Reading (DECR)

Although rich evidence supported the effectiveness of DECR in developing high-level reading skills (e.g., reading strategies, comprehension skills) and facilitating overall understanding of reading contexts (e.g., Chen & Chen, 2014; Kim et al., 2006), the previous research was limited. First, the developments of two basic reading skills, namely, skimming and scanning, were underexplored. To compensate this, our study explores the developments of skimming and scanning techniques (SSTs), which could assist EFL learners' reading comprehension by preventing them from 'inefficient reading habits such as word by word, reading aloud, moving lips, translating, reading for form and details (Ngoc, 2015, p. 197)'. Second, the advantages of group work were recognized, while the influences of group size on collaboration efficiency were unclear (Slof, van Leeuwen, Janssen, & Kirschner, 2021). For example, Chang and Hsu (2011) arranged students into two-, three-, four-, and five-person groups to learn with the PDA-supported collaborative translation-annotation system for identifying the optimum group size. The results indicated that participants who read in small groups of two, three, and four outperformed those of individual reading. However, a group of five was ineffective. Strauß and Rummel (2020) recommended four-person group. This study therefore takes the group size ranging from two to five into consideration. Five-person group is the upper bound because a large group reduces the contributions of individual group members (Strauß & Rummel, 2020). Third, most studies on DECR were concerned with while-reading process and reading performances of learners, but they little engaged learners with pre-reading activities (e.g., Andoko et al., 2020; Liu, Chen, & Chang, 2010), which indicates the necessity to design pre-reading activities in DECR.

2.2. Concept Mapped Pre-reading Activity

Concept mapping is commonly used in reading comprehension, enabling learners to organize the reading contents through visual aids such as boxes, circles, linking words, cross-linking words, links, and cross-links (Andoko et al., 2020; Novak & Cañas, 2006). It helps learners organize, review, and recall information from a text in a more efficient manner (Liu et al., 2010). Hwang, Chen, Sung, and Lin (2019) found that learners learned with concept map-based summarization strategy exhibited better summarization skills and slightly lower cognitive load than the counterparts with the summarization strategy. However, learners might have difficulties making their concept maps from scratch (Hwang et al., 2019). A possible solution is to ask learners to construct a map collaboratively, which may increase learners' involvement and consequently the rate of reading comprehension, because collaborative concept mapping allows mapmakers to express personal understanding of the reading context to partners through communication and discussion. Therefore, the current study introduces group concept mapping to learners.

Concept mapping is mainly based on meaningful learning (Novak & Cañas, 2006). Meaningful learning is the process where 'new knowledge is consciously linked to existing specifically relevant concepts and propositions in cognitive structure and incorporated into these concepts' (Novak, 1980, p. 61). In this study, concept mapping could facilitate meaningful learning process as it requires learners to extract concepts from the reading contents, and then organizing these concepts hierarchically to form an integrated, coherent framework of the reading contents.

2.3. Research Question

Based on above justification, this study aims to determine the facilitative group size (two to five persons) in the *Xiaohuazhuo*-based group concept mapping for developing learners' skimming and scanning skills, by answering the following questions:

(1) Does the group size impact learners' skimming and scanning skills, overall reading comprehension performance, and concept mapping performance in *Xiaohuazhuo*-based group concept mapped pre-reading (XGCMP) activity?

(2) What is the collective efficacy of students in two-, three-, four-, and five-person groups in XGCMP activity?

(3) Do students in small groups of two, three, four, and five satisfy the introduced XGCMP activity?

3. Method

3.1. Participants

The researchers intend to recruit 97 students from the same major in a junior college in mainland China. The participants will be randomly divided into pairs (N= 24), triads (N= 24), four-and five-person groups (N= 24; N=25).

The teacher of participants is also involved in this study. She is the classes' regular teacher, delivering pre-experiment instructions and assisting the researchers in scoring concept maps and reading comprehension.

3.2. Research Design

This study lasts for three weeks (see Figure 1). On the first week, all participants take the pre-test (Reading comprehension 1) and receive the pre-experiment instructions (i.e., concept mapping and XGCMP). In week two, groups of two, three, four, and five co-construct the concept map for Reading comprehension 2 and answer the questions individually. During this process, students shared the workload by playing different roles (e.g., note-recorder, concept-identifier, mapmaker, and editor) that arranged by the teacher. The teacher provided the same feedback to all participants in terms of their strengths and weakness and possible suggestions to make improvements. On the last week, each participant constructs a concept map for Reading comprehension 3, answers the reading questions, and responds to the questionnaires. The independent variable is concept-mapped pre-reading activity; the dependent variables include overall reading performance, SSTs, concept map scores, collective efficacy, and satisfaction. Other control variables are the instructor, instructional material, and students' initial reading performances.

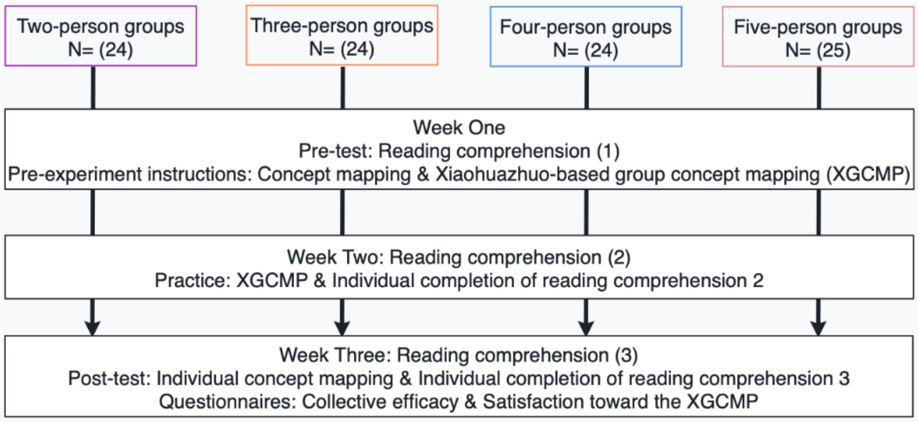

Figure 1. Research design

3.3. Reading Comprehension

Three reading texts from past College English Test 4 (CET4) are selected. The topics of them are '*Textbooks*', '*Work-life balance*', and '*Bike*'. The consideration of selecting them is that the identified texts cannot be too challenging because most participants are of intermediate-level English proficiency. If the text is too difficult, the participants would be reluctant to participate, leading to negative influences on the research results. Each reading text is designed with five multiple-choice questions (e.g., Chen & Chen, 2014; Kim et al., 2006) to examine learners' SSTs.

3.4. Questionnaires

Two questionnaires are used in this study. One evaluates participants' collective efficacy. It was adapted from Wang and Lin (2007), originally developed by Pintrich (1991), including eight items such as '*I believe that our group can achieve superior outcomes in this reading course*'. The other is adapted from Chu, Hwang, Tsai, and Tseng (2010), assessing participants' *satisfaction toward the XGCMP*. It included nine items; an example of which is '*The mission of applying XGCMP makes me better understand how to complete reading comprehension*'. The questionnaires applied a five-point Liker scale ranging from '*Strongly disagree* (1)' to '*Strongly agree* (5)'.

3.5. Scoring Rubrics

Scoring rubrics for concept map and reading comprehension are described. For one thing, the scoring model for the concept map is adapted from Gowin and Novak (1984). The scoring criteria are (1) one point for a meaningful relationship between two concepts; (2) ten points for every valid cross-link; (3) five points for a valid hierarchy; (4) one point for each example. For another thing, each reading comprehension consists of 5 multiple-choice items, with some of them relating to the skimming skill and the rest is about the scanning skill. The correct answer for each multiple-choice item can get 2 points, and incorrect answers and no response to the item are marked with zero point. The overall reading performance is the sum of the scores for five items.

3.6. Data Collection and Analysis

Various data are collected to explore the influence of group size on the learners' reading performance and their affective statuses in the XGCMP. Accordingly, different methods are used to analyze the data.

To answer the first research question, our study applies paired sample *t* tests, MANOVA, and ANOVA. Specifically, paired *t* tests compare pre- and post-skimming, scanning, and overall reading comprehension scores. MANOVA assesses the difference of Reading comprehension 3 across two-, three-, four-, and five-person groups. ANOVA explores whether groups with different group size differ in post-concept map scores.

To answer the second and third research questions, our study conducts two one-way ANOVAs to analyze the between-group difference in collective efficacy and satisfaction toward the XGCMP.

4. Future Work

Now, the researchers are negotiating with one teacher to invite her students to participate in this study. We also explain the instructional materials (concept mapping, *Xiaohuazhuo*, XGCMP, and the scoring rubrics) to the teacher. After achieving her consensus, we will conduct a small-scale pilot study among other non-participant learners in advance, and then revise the research design accordingly. Subsequently, the formal study will be implemented.

Acknowledgements

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Integrating Computational Thinking into Mathematics Education

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Abstract: *The Education Bureau (EDB) of Hong Kong has published an official document related to computational thinking (CT) and coding education in 2020, named as the "Computational Thinking - Coding Education: Supplement to the Primary Curriculum", to facilitate teaching and learning of computational thinking and coding education in local senior primary schools. At the same time, the Curriculum Development Council (CDC) of Hong Kong has also encouraged and recommended schools to promote a school-based CT education, to meet the needs of 21st century learners. To examine the effect that integrating computational thinking into mathematics education in senior primary education, a 3-year research will be conducted from January, 2021 to December, 2023, to demonstrate the importance of the concepts of integrated teaching which may change teachers' views from teaching computational thinking to programming independently, to considering teaching computational thinking as applicable to any other fields, especially in mathematics education. In addition, the study aims at helping computational thinking educator to understand what computational thinking is, how to teach computational thinking in mathematics education as an integrated subject, and to develop computational thinking educator the essential skills and pedagogical knowledge in teaching computational thinking activities.*

Keywords: *Computational Thinking, Mathematics, Education, Integrated, Coding*

1. Introduction

The Curriculum Development Council (2020) has released an official document about computational thinking education named as "Computational Thinking – Coding Education: Supplement to the Primary Curriculum", which is recommended for use in schools by the Education Bureau of The Government of the Hong Kong Special Administrative Region. The document focuses to provide a detailed and systematic content of computational thinking and coding education, which includes, but not limited to, learning elements which is applicable to senior primary education, lesson arrangement and implementation, principles of teaching and learning, as well as assessment arrangement (The Curriculum Development Council, 2020).

Nowadays, many researchers, education advocates and curriculum leaders believe that, there is a close relationship between computational thinking and mathematics education, this is also suggested that the focus of mathematics education should be shifted from a knowledge content based to a more skills-based curriculum, especially computational thinking skills (Sung et al., 2017). At the same time, Israel and Lash (2020) points out that, there are three relationship in term of integrated teaching of computational thinking and mathematics education, which are, no integration, partial integration and full integration, respectively.

However, there is lack of studies about integrating computational thinking into mathematics education (Hickmott et al., 2018). Therefore, Lee et al. (2019) believe that there is a significant research gap in integrating computational thinking into mathematics education.

2. Literature Review

Computational Thinking (CT), is a term used since the 1950s (Angeli & Giannakos, 2020). With the rise of information and communication technologies (ICT) in the 21st century, CT skills become one of the most important skills that help students develop essential and attractive skills for cognitive development and future employment opportunities. Therefore, Reichert et al. (2020) believes that computational thinking education must occur through pre-existing subjects in the basic education curriculum, especially in mathematics education.

This section provides a literature review about computational thinking, mathematics education and integrated computational thinking and mathematics education by using four databases, which are, British Education Index, Eric, Academic Search Ultimate, and Education Research Complete. The search string is set to be TI ((computational thinking or algorithmic thinking or programming or coding) AND (math or mathematics or maths or math education) OR AB ((computational thinking or algorithmic thinking or programming or coding) AND (math or mathematics or maths or math education) with limiters of the Published Date: 20110101-20201231.

There are a total number of 475 academic journal articles being recorded through database searching, 81 records were removed with duplicated results. Therefore, 394 records are screened, then 385 articles are excluded and 9 articles are selected for full-text study, whereas 3 full-text articles were excluded due to full-text unavailable online.

In short, many governments have been prompting computational thinking education recently, as computational thinking is an essential and important skill in 21st century, which support students' cognitive developments as well as higher-order thinking (Sáez-López, Sevillano-García & Vazquez-Cano, 2019; Miller, 2019; Falloon, 2016).

At the same time, computational thinking skills not only has a positive impact on students' development, but also plays an important role in mathematics education. Miller (2019) and Rich et al. (2020) claim that, the conceptual framework and development of computational thinking and mathematics education are connected. Fallon (2016) believes that, computational thinking education assists with the development of mathematics education. Specifically, computational thinking may help students to develop long-lasting mathematical understanding and to learn expressing and communicating using mathematical language (Sáez-López, Sevillano-García & Vazquez-Cano, 2019; Israel and Lash, 2020; Rodríguez-Martínez et al., 2020).

Also, Sáez-López, Sevillano-García & Vazquez-Cano (2019); Miller (2019) & Falloon (2016) claim that, modern teaching and learning strategies are needed for implementing computation thinking education into mathematics education, such as project-based learning, meaningful learning, constructivism, hands-on activities and discovery learning.

Moreover, researches' results show that, students' higher-order thinking skills, mathematical thinking skills, generic skills and understanding of mathematical concepts are enhanced through integrating computational thinking into mathematics education (Falloon, 2016; Sáez-López, Sevillano-García & Vazquez-Cano, 2019). More precisely, computational thinking may also help students to enhance mathematical patterns and structures' understanding, sequencing, lopping and conditional logic (Miller, 2019; Israel and Lash, 2020; Rodríguez-Martínez et al., 2020).

There are some research gaps being leaded based on the findings and the limitation of the selected articles, such as, how to integrate the teaching of computational thinking into mathematic education effectively; what are the pedagogical knowledge that teacher candidates are required in teaching the integrated subject and more.

3. Aim and Objectives

Since Gadanidis et al. (2017) claims that, many teachers do not understand what computational thinking education is, what it involves and why it is important, also, more than half of the teachers who are currently teaching computational thinking only teach computational thinking education as an isolated subject, such as computer science and programming, instead of teaching as an integrated subject, such as science, technology, engineering and mathematics (STEM) or integrating computational thinking into mathematics education. Therefore, the aims and objectives of conducting the study about integrating computational thinking in mathematics education, is to demonstrate the importance of the concepts of integrated teaching with computational thinking which may change teachers' views from teaching computational thinking to programming independently, to considering teaching computational thinking as applicable to any other fields, especially in mathematics education.

At the same time, Lye and Koh (2014) point out that, many teacher candidates do not have clear understanding on how to develop computational thinking skills in the classroom. Hence, there is a critical need in preparing computational thinking education's teacher candidates to integrate computational thinking in their daily teaching and learning activities through enhancing their pedagogical knowledge, content knowledge and more importantly, the pedagogical content knowledge of integrating computational thinking in mathematics education.

Therefore, the study aims at helping computational thinking educator to understand what computational thinking is and how to teach computational thinking in mathematics education as an integrated subject, and to develop computational thinking educator the essential skills and pedagogical knowledge in teaching computational thinking activities.

4. Research Gaps and Research Questions

Rodríguez-Martínez, González-Calero & Sáez-López (2020) claim that most of the current researches about integrating CT in ME are focusing exclusively on secondary school education. Therefore, research and study of CT and ME integration on primary school education is in strong need. Besides, more researches of integrating CT in ME on primary school curriculum with larger sample size and wider scope are needed, by considering existing research with the mentioned major findings and limitation, there are some suggestions for future research as discussed below.

Firstly, the relationship between CT and ME, has not yet been clarified. For example, does improvement on CT enhance students' performance on ME, or improvement on ME enhance students' performance on CT, and what are the relationship between the performance on ME and performance on CT, which future study on the relationship, such as correlation coefficient of CT and ME is needed, as well as the effects of scaffolding in the integrated teaching.

Secondly, students learning motivation and interest on integrating CT in ME has not yet been studied. Future research should study whether if students have relatively higher learning interest and motivation in learning mathematics with CT integration, comparing with no integration, as an isolated subject.

Lastly, asynchronous learning of integrating CT in ME has not yet been elucidated. Therefore, there is a research gap for researcher to study the possibility of implementing asynchronous learning of integrating CT in ME.

5. Research Design and Methods

The study is expected to be completed in 3 years starting from January, 2021 to December, 2023. The timescale includes preparing proposal of the study, conducting a literature review, submitting conference proposals and manuscripts to journals, processing of data collection and analysis, as well as writing the study.

In the research, both quantitative and qualitative research methods will be used. For quantitative research method, several questionnaires will be designed for students and teachers to study their attitude and value towards teaching and learning computational thinking with mathematics education; quasi-experimental research of experimental analysis will be conducted to test students' performance in integrating computational thinking with mathematics education, descriptive analysis will be used such as measures of frequency, central tendency, dispersion, variation and positions of data, inferential statistics for analyzing the data, whereas hypothesis tests such as T-Test, Chi-Square, and ANOVA will be tested. For qualitative research method, individual interviews will be conducted to key person, such as principal, curriculum leader and panel heads; three focus groups will be designed to examine the effect of integrating computational thinking and mathematics education; and an in-person observation will also be conducted to observe the teachers and students' interactions and reactions in-class.

5.1. Data Collection and Participants

Both primary data and secondary data will be collected for the study. Firstly, primary data will be collected directly from main sources, such as teachers and students' surveys, interviews and experiments. To collect the first-hand data from human participants, a completed application form for ethical review and a sample of the consent form and information sheet with the research proposal will be submitted to the graduate school to seek for approval. Secondly, secondary data will also be collected and analyzed for literature review, to expand the scope of the research, and support the findings and results, such as previous studies, publications, national statistics and more.

The researcher has been working as a Curriculum Developer and Panel head of Information and Communication Technology and Science, Technology, Engendering and Mathematics Education (ICT & STEM), as well as a Vice panel head of Mathematics Education. Therefore, the primary data will be mainly collected in Po Leung Kuk Hong Kong Taoist Association Yuen Yuen Primary School, which is an English medium instruction's Direct Subsidy Scheme School, located in New Territories, Hong Kong.

In addition, other primary schools and secondary schools may also be invited to be the participants of the study. At the same time, secondary data, will be collected within 20 years of study, such that, from January, 2000 to December, 2019. The concepts of triangulation in research will be considered when designing methods for collecting and analyzing both primary and secondary data.

6. Significance

The study may impact different stakeholders, such as students, parents, teachers, schools, sociality and the education system in Hong Kong. Besides impacting individual, the study may also have impacts on the society, such as national education policy, structure of the current school system and the society.

Firstly, from a macro view, the study may help in re-establishing national vision and educational aims, as well as restructuring school system. With the emphasizes of integrating computational thinking into mathematics education, government of different countries may take it as reference to re-establishing national vision, educational aims and system to meet with the needs of the twenty-first century. Secondly, from a meso view, the stakeholders being affected includes principals, teachers and parents. The number of computational thinking education's professional development of teachers and principals may be increased, parental and community Involvement may also be affected. Thirdly, from a micro and operational view, the study may lead into a paradigm shift in teaching, learning and curriculum Innovative. More lesson time for teaching computational thinking will be implemented, mathematics teachers may need to integrate coding and computational thinking education into mathematical concepts' teaching and learning activities, such as leaning negative number, degree, and coordinate system through the learning of using Scratch, App Inventor and micro: bit programming.

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Research Proposal: The Influence of Gamification in the Flipped Classroom on Learner Achievement and Engagement for Adult Business Education in China

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Abstract: *The key to higher education for business is the application of knowledge to solve real-world business problems. Therefore, devising and investigating new pedagogical approaches that change the dominant transmission-based knowledge dissemination in business schools is in need, with the light that those new approaches may improve the learning achievement of adult learners. The overarching goal of this study is to propose an effective way to engage adult learners in applying their knowledge learned to solve real-world business problems through knowledge and experience sharing. The study will test the use of a gamified flipped classroom approach and examine its influence on learner achievement and engagement. In the flipped lessons, learners will learn some basic materials before class via pre-recorded instructional videos. They will then engage in solving real-world problems collaboratively inside the classroom. Drawing upon self-determination theory, game-design elements (e.g., points, badges, and a leaderboard) will be used to support learners' psychological needs and enhance their engagement. The study will be conducted in a 20-week postgraduate adult business program in China. An explanatory sequential design of the mixed-methods approach will be used. Three instructional conditions (about 25 learners each) will be compared: gamified flipped classroom, non-gamified flipped classroom, and gamified traditional classroom. The major data sources include learner artifacts, class observation reports, surveys, and participant interviews. The significance of this study lies in devising a feasible pedagogical approach to contribute to higher learning achievement and engagement of adult learners in higher education for business.*

Keywords: flipped classroom, gamification, self-determination theory, business education, adult learning

1. Introduction

As a consequence of critics about the graduates lacking the capability to apply the knowledge learned in solving problems in real life, higher education of business schools now has to search for a more effective pedagogical approach (Wilson & Thomas, 2012). The advent of information communication technology has led to the feasibility of innovative arrangements of classroom teaching. Peer learning with explicit sharing of practical experience and knowledge is one of the options proposed for adult learning in business schools (Boud et al., 2014). However, traditional didactic lecturing is still commonly found in China higher education including business schools, which is not an effective way to cultivate enthusiastic engagement and peer interactions in the classroom settings (Li et al., 2020).

In this regard, the flipped classroom is introduced as an educational approach for adult learners, in which instructors provide pre-recorded teaching contents before class and spare equivalent class time for knowledge application rather than passive didactic lecturing (French et al., 2020). However, research is still required to increase learner achievement and engagement in the flipped classroom (Huang et al., 2019). Based on the self-determination theory, gamification has the potential to meet the three innate psychological needs (i.e., autonomy, relatedness, and competence) of the learners (Ryan & Deci, 2017; Sailer & Sailer, 2021). Therefore, this study aims to investigate the influence of gamification on the flipped and traditional classrooms on learner achievement and engagement in the context of postgraduate business education in China. The following two major research questions guide the study:

1. How does gamification influence the flipped and traditional classrooms on learner achievement?
2. How does gamification influence the flipped and traditional classrooms on learner engagement?

2. Literature Review

2.1. Flipped Classroom

The flipped classroom is a presumably pedagogical approach to address the issue of graduates from business schools of higher education being criticized as without the ability to copy with business management in reality (Burton & Wedemeyer, 1992). With the aids of information communication technology, learners gained their first exposure to learning instruction via pre-recorded instructional videos before class, which allows more time for in-class activities to focus on knowledge applications and problem-solving discussion (Hwang & Chen, 2019; Li et al., 2020). However, not all research on the flipped classroom shows promising results. For example, Boevé et al. (2017) revealed that the behavior of learners in the flipped classroom appeared to be similar to their counterparts in the non-flipped classroom. Tse et al. (2019) even discovered that learners have significantly lower motivation in their flipped class as compared to the traditional one in which both classes have no game design element applied. As Zainuddin (2018) suggested, there is a need to re-design the flipped classroom with a novel extension to increase learner engagement, such as participation.

2.2. Gamification

Gamifying the flipped classroom with game-design elements such as points, badges, and leaderboards is a strategy to encourage learners to watch the pre-recorded instructional videos and better mastery of the course materials before class (Brunsell & Horejsi, 2013; Huang et al., 2019). Points, badges, and leaderboards are the most commonly used game design elements for more engaging learning (Huang & Hew, 2015).

In fact, applying game-design elements in non-game contexts or "gamification," as Deterding et al. (2011) defined, has been widely implemented in education contexts. Research suggested that gamification can motivate learners to learn as it can be an effective tool for enhancing learner engagement (Domínguez et al., 2013). Therefore, there is a high prospective for applying gamification in the flipped classroom and also the traditional classroom to improve learning achievement and engagement. Nevertheless, research on the use of this pedagogical approach in adult education is relatively limited (Surendeleg et al., 2014).

2.3. Self-determination Theory

According to self-determination theory, learners are motivated and engaged in a learning activity when three innate psychological needs of autonomy, relatedness, and competence are fulfilled (Ryan & Deci, 2017). According to Sergis et al. (2018), the fulfillment of these three needs will motivate learners to engage in pre-class learning tasks and in-class sessions. The flipped classroom provides the flexibility of learning time management, varying levels of difficult tasks for learners to choose giving learner autonomy (Abeysekera & Dawson, 2015). With their autonomy need supported, learners' behavioral and emotional engagement increase (Skinner et al., 2008). Game-design elements such as points, badges, and leaderboards can provide immediate task-level feedback, constructive social interaction to allow further promotion of peer cooperation and mutual supports (Rigby & Ryan, 2011). Accordingly, both competence and relatedness needs can also be fulfilled (Sailer & Sailer, 2021).

3. Method

3.1. Context and Participants

The purpose of this study is to examine the influence of gamification on learner achievement and engagement of the traditional and flipped classrooms in the context of postgraduate business education in China. Students enrolled have to complete four modules in a 20-week semester (Figure 1). In this study, three pedagogical approaches will be compared: (1) gamified flipped classroom (GFC), (2) non-gamified flipped classroom (NFC), and (3) gamified traditional classroom (GTC). Each approach will involve one class of about 25 students (i.e., a total of about 75 students in the three classes). It is expected that all student participants are working adults aged 25-40 years old, with working experience for more than 5 years.

20-week Semester		GFC	NFC	GTC	
Week 1	Pre-class	Text books	Text books	Text books	
Week 2	Pre-class				First module
Week 3	Pre-class				
Week 4	Module #1	Classroom learning #1	Classroom learning #1	Classroom learning #1	
Week 5	Post-class	Essay assignment	Essay assignment	Essay assignment	
Week 6	Pre-class	Pre-recorded video	Pre-recorded video		
Week 7	Pre-class				
Week 8	Pre-class				Second module
Week 9	Module #2	Classroom learning #2	Classroom learning #2	Classroom learning #2	
Week 10	Post-class	Essay assignment	Essay assignment	Essay assignment	
Week 11	Pre-class	Pre-recorded video	Pre-recorded video		
Week 12	Pre-class				
Week 13	Pre-class				Third module
Week 14	Module #3	Classroom learning #3	Classroom learning #3	Classroom learning #3	
Week 15	Post-class	Essay assignment	Essay assignment	Essay assignment	
Week 16	Pre-class	Pre-recorded video	Pre-recorded video		
Week 17	Pre-class				
Week 18	Pre-class				
Week 19	Module #4	Classroom learning #4	Classroom learning #4	Classroom learning #4	Forth module
Week 20	Post-class	Essay assignment	Essay assignment	Essay assignment	

Figure 1. Class rundown.

3.2. Research Design

All three classes will start with traditional teaching for the first module, and the final scores of that module (i.e., the result of the post-module individual essay assignment) will be regarded as students' pre-intervention ability reference. Then, the classes will be assigned to one of the three instructional designs (i.e., GTC, NFC, and GFC) starting from the beginning of the second module (i.e., Week 6). The problem-based instructional model applies to the in-class learning activities, which is sufficiently adaptable to fit in traditional lectures and educational settings (Boud & Feletti, 1997).

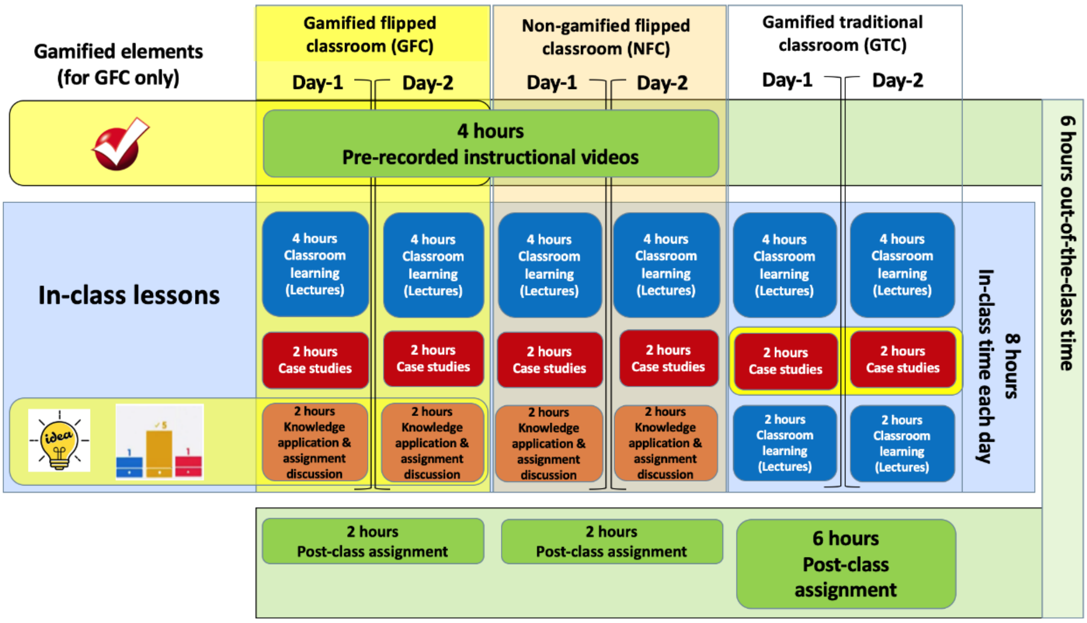

Figure 2. Research design.

Originally, students enrolled in the program will have 16 hours of in-class lessons (8 hours each day), and 6 hours post-class assignment writing for each module. Therefore, a total of 22 hours to complete a module, and 4 modules in a semester for all three classroom groups (Figure 1). For the GFC and NFC, the in-class lessons of the modules will be redesigned. Pre-recorded instructional videos (a total of 4 hours) will be provided three weeks before the classroom session on the learning management system – Moodle. Then, there will spare 2 hours of in-class time each day for knowledge application and assignment discussion (Figure 2). The only difference between the GFC and NFC is the application of gamification. Moreover, game-design elements will be used in both the GFC and GTC, but not in the NFC. Game-design elements (e.g., task completion points, good comment/new idea badges, and a leaderboard) will be applied in pre-class learning tasks of GFC and in-class sessions of both GFC and GTC.

For the 16-hour in-class lessons of the GTC, the instructor will teach in a traditional instructional approach which mainly comprises lectures and case studies with game design elements applied.

3.3. Data Collection and Analysis

Data will be collected to evaluate learner achievement and engagement. Learner achievement will be measured by the result of individual assignments. Learner engagement (i.e. behavioral, cognitive, and emotional) will be evaluated by post-module questionnaires, class observation reports, and learner interviews.

An explanatory sequential design of the mixed-methods approach will be adopted, which is the approach to have qualitative data in explaining quantitative results. This approach is useful when the research is going to assess trends and relationships with quantitative data and also wants to understand the mechanism and reasons behind it (Creswell et al., 2011). Both qualitative and qualitative data will be processed and analyzed accordingly base on the procedures of Field (2009) and Creswell et al. (2011).

4. Significant of Study

As there is a call for breakthroughs in higher education in China (Abrami et al., 2014), research on new pedagogical approaches with technology application becomes highly relevant (Bates & Sangra, 2011). This study focus on the gamified flipped classroom with a self-determination theoretical framework in the context of adult business education hopes to shed further light on the topic.

5. Issues to be discussed in the Conference

Technology application in higher education and adult learning is the area of our study. We focus on the achievement and engagement of adult learners with gamified flipped classroom and gamified traditional classroom approaches. We would like to explore more in detail the constructive usage of in-class sessions to enable knowledge application that is deemed as most valuable for adult learners (Taylor et al., 2000).

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Research on Programming Instructional Strategies for Secondary Novice Learners from the Perspective of Learning Analytics

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1. Research aim

This study will explore the effectiveness of programming instructional strategies by means of learning analytics and multi-dimensional data collection and analysis. The research mainly takes secondary novice learners as the research object, designs and integrates various instructional programming strategies, investigates the effectiveness of these instructional strategies through a series of empirical studies, and constructs the corresponding instructional strategy model and proposes suggestions and enlightenment for programming instruction for secondary novice learners. Among them, the important research aims are:

(1) Comparing with instructor-directed lecturing, sub study 1 tries to integrate learner-centered unplugged programming to promote programming knowledge gains and attitude towards programming of secondary novice learners, and discover learners' behavior sequence through quantitative analysis and learning analytics to better reveal the process-oriented difference between two instructional modes.

(2) Based on the learner-centered concept and collaborative learning theory, sub study 2 conducts an empirical study on students' collaborative behavior, discourses and perceived attitudes in the process of pair programming by quantitative analysis and learning analytics, and tends to find out the pedagogical and instructional implications for conducting pair programming instructional strategy among secondary novice learners.

(3) Combining instructional strategies discovered in above two studies, sub study 3 takes a deeper look inside the programming modality itself, and utilize different programming modalities (block-based and text-based) to help learners transits to formal Python programming for secondary novice learners. Through quantitative analysis, learning analytics and programming platform data analysis, the differences between the two introductory programming learning methods are explained with fine-grained and multi-dimensional data.

(4) Grounded upon the conclusions and implications summarized from learner-centered instruction, pair programming strategy and integration of different programming modalities, this research aims to propose instructional models for programming education of secondary novice learners (see Figure 1).

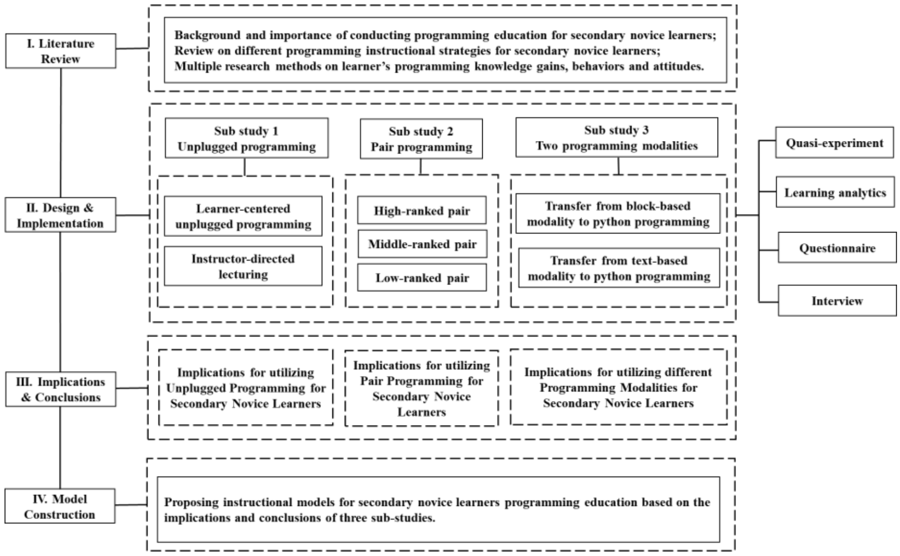

Figure 1. Research model.

2. Research background

Grounded upon the social, cultural, situated perspectives of learning (Vygotsky, 1978), learning is an active, constructive process through which learners actively construct their own understandings through interacting with peers, resources and technologies. The computer programming is one of the main learning modes to improve students' computational thinking (CT) in K-12 schools (Wing, 2006). Although computer programming has potential to improve CT, empirical studies show that novice programmers easily become frustrated and bored when encountering challenges during the programming process (Falloon, 2016). In the formal programming education, emerging instructional strategies, e.g., unplugged, game-based, or project-based programming, have been used in informal learning to transform the instructor-directed lecturing of programming knowledge to the pragmatic, learner-centered programming practices (Brackmann et al., 2017; Hosseini et al., 2019; Nurbekova et al., 2020). Among those practical strategies, unplugged programming is a hands-on activity of programming concepts without the use of computers or other electronic technologies to contextualize computational algorithms through physical or kinesthetic activities (Bell et al., 2009). Research argues that unplugged programming activities can simplify computational concepts for learners and therefore promote their programming engagement, motivation, and interest (Looi et al., 2018). But few studies actually examine how students engage in the programming practices from a process-oriented perspective, and to what extent unplugged programming activities foster student learning (Huang & Looi, 2020). In response to this research gap, this quasi-experimental research (sub study 1) designed and implemented the learner-centered unplugged programming in China's secondary education and compared the effects of the unplugged programming activities on student learning with the traditional instructor-directed lecturing mode.

Compared to solo programming, pair programming, as a collaborative learning mode, is a pragmatical strategy for students to solve challenging problems, generate creative ideas, and promote their learning experiences (Demir & Seferoglu, 2020a). However, previous empirical research shows discrepancies about the effect of pair programming on student learning. While some empirical studies indicate that pair programming results in positive programming learning processes and performances (e.g., Hannay et al., 2009; Kalaian & Kasim, 2014), other studies show that pair programming may undermine students' problem-solving due to a lack of skills in organization, communication, and collaboration (e.g., Papadakis, 2018; Veerasamy et al., 2019). Given the complex factors that may influence the pair programming, this study (sub study 2) uses the pair programming strategy, supported with the Minecraft platform, to facilitate computer programming in China's secondary education context. Using a mixed-method approach, this study deliberately chooses and analyzes three pairs' collaborative behaviors, discourses, and perceptions during the pair programming processes.

A large number of case studies have documented the challenges associated with the transition between block-based and text-based programming languages. Among them, Armoni et al. (2015) conducted a longitudinal study and found, in some specific fields like iterative structure, those students with Scratch learning experience are better than their peers in text-based environment. Grover et al. (2015) indicated that block-based programming course can prepare learners for text-based programming learning, especially in multiple-choice questions of text-based programming concepts. Dann et al. (2012) showed that students performed better in Java courses after completing the introductory course (Alice) for the purpose of transition. However, Weintrop and Wilensky (2019) advocated that more rigorous empirical evidences using multi-dimensional analysis are needed to reveal the better integration of two programming modalities to further facilitate novice learner. Thus, this quasi-experimental research (sub study 3) designed and implemented the text-based and block-based programming instruction in China's secondary education and compared the students' learning outcome when transiting from different modalities to python programming.

From an analytical perspective, multiple learning analytics methods have been used in previous empirical research in the collaborative learning field (Ouyang et al., 2020), which further lead to the use of mixed method for revealing a fine-grained picture of programming process (Pereira et al., 2020). Recent work started to use the mixed methods to gain a fuller picture of programming from both quantitative, sequential, and qualitative perspectives. For example, Wu et al. (2019) combined statistical inference with the interpretation of qualitative, grounded analysis – to analyze the collaborative programming activities of a high-performing group and a low-performing group. They also integrated the lag sequential analysis in this study to examine students' behavioral patterns during the programming process. Overall, following the research trend, this study uses the mixed method to better understand secondary novice learners' programming learning from the multi-dimensional perspectives.

3. Research methodology

3.1 Sub study 1 – learner-centered unplugged programming vs instructor-directed lecturing

The research context of sub study 2 is a compulsory course titled "Creative Programming Algorithms" offered at a junior high school in the Eastern area of China. Under the COVID-19 period, learners were not allowed to get access to the computer labs; instead, the classes were offered in a normal classroom with interactive whiteboards. This research used a quasi-experimental design to investigate the differences of learners' knowledge gains, in-class behaviors, and attitudes changes under the control condition (Instructor-directed lecturing, IDL) and experimental condition (learner-centered unplugged programming, UPP). There were 31 learners (female =16; male =15) in the IDL class and 32 learners (female =19; male=13) in the UPP class. Classes were taught by the same instructor, who maintained the same teaching style under two conditions, offered the same instructional materials to learners, and used the same teaching guidance for each class, except the use of the unplugged programming activities in the experiment condition.

This sub study collected and analyzed data in four ways. First, we conducted pre and post assessment of learners' computer programming knowledge and skills. The computer programming knowledge test comprised of 10 multiple-choice questions on the programming concepts and 2 fill in blank questions related to the programming comprehension and non-programming questions on algorithms. Adapted from the computational thinking scale (CTS), the computer programming skills tests contained 5 dimensions and 29 measurement indicators (Korkmaz et al., 2017). Independent T-test analysis was applied to compare the post-test of CT skills between two instructional modes.

Second, we recorded videos of two classes (without audios) to capture learners' behaviors. We deliberately chose the last two courses classes as the video data for the current research (45 minutes/class; a total of 180 minutes). Video analysis was used to code learners' in-class behaviors emerged during learning and instruction processes (Kersting, 2008). Two coders reached an inter-rater reliability with the Cohen's Kappa of 0.888 Two coders reached an inter-rater reliability with the Cohen's Kappa of 0.801 and identified six behaviors: *Listening to Instructor* (LtI), *Discussing with Peer* (DwP), *Asking Questions* (AsQ), *Answering Question* (AnQ), *Taking Notes* (TN) and *Irrelevant Behavior* (IB). Furthermore, based on the video coding results, the lag-sequential analysis (LsA) was used to analyze learners' behavioral patterns (Faraone & Dorfman, 1987), including the transitional frequencies between two behaviors and the visualized network representations in two instructional modes.

Regarding learners' change of attitudes, pre- and post-surveys were conducted at the beginning and the end of the classes. The survey was adapted from the Georgia Computes project (Bruckman et al., 2009) and the Computing Attitudes Survey (Dorn & Tew, 2015). The survey included five 5-point Likert scale questions ranging from 1 (strongly disagree) to 5 (strongly agree), as well as short open-ended questions. Independent T-test analysis and descriptive analysis were used to reveal the differences of learners' confidence, enjoyment, and future interest between two instructional modes. Finally, we invited students to a semi-structured interview at the end of the class. The interview focused on learners' recall of the knowledge they learned from the class, the most difficult or easiest part of the class, as well as their self-perceptions and future plan on computer programming. Thematic analysis was used to analyze the interview data (Cohen et al., 2013).

3.2 Sub study 2 – pair programming for high, middle and low pairs

The research context of sub study 2 is a selective course titled "The Interactive Programming in Minecraft" offered at a junior high school in the Eastern area of China. This course is not a required course; students take the course autonomously based on their own choices. Twenty 7th graders (2 females, 18 males) enrolled in this 12-week course; they were all novice programmers with no text-based Python language programming experiences. Students were designated into ten pairs at the beginning under the instructor's arrangement. Among ten pairs, we identified three contrasting pairs based on students' individual procedural performance scores, they were identified as high-ranked, middle-ranked and low-ranked pair.

Focusing on three pairs' programming processes, sub study 2 collected and analyzed data from three ways. First, we recorded students' online and offline behaviors through the computer screen-running videos and a whole class video (without sounds). Click stream analysis (Filva et al., 2019) and classroom video analysis (Kersting, 2008) were used to analyze those two types of data in order to identify pairs' programming behaviors. Two coders reached an inter-rater reliability with the Cohen's Kappa of .888. Eight behaviors were identified: *Project Understanding* (PU), *Python Coding* (PC), *Minecraft Debugging* (MD), *Minecraft Gaming* (MG), *Programming Assistance* (PA), *Partner Discussion* (PD), *Instructor Communication* (IC) *and Classmate Communication* (CC). Students' behaviors were reported in a summative way and further demonstrated in a temporal graph.

Second, we recorded students' communicative discourses during the pair programming processes. We used the quantitative content analysis (QCA) (Grbich, 2007), lag-sequential analysis (LsA) (Faraone & Dorfman, 1987) as well as ethnographic interpretations (Wu et al., 2019) to examine and explain pairs' discourse patterns and characteristics. Two raters reached an inter-rater reliability with the Cohen's Kappa of 0.802 and identified eight codes: *Programming Exploration* (PEx), *Programming Elaboration* (PEl), *Asking Question* (AsQ), *Answering Question* (AnQ), *Instructor Interaction* (II), *Social Expression-Positive* (SE-P), *Social Expression-Negative* (SE-N) and *Social Chatting* (SC). We also used ethnographic accounts to explain excerpts from groups' communicative discourses that complemented the previous analysis results. Finally, we collected and analyzed students' self-reports about their psychological changes (e.g., anxiety) and students' interview data regarding perceptions about the collaborative programming processes.

3.3 Sub study 3 – block-based vs text-based programming modality

The research context of sub study 3 is a compulsory course titled "Information Technology" offered at a junior high school in the Eastern area of China. This research used a quasi-experimental design to investigate the differences of learners' programming behavior and programming knowledge gains in text-based (TM) and block-based modality (BM). There were 32 learners (female = 13; male = 19) in TM class and 32 learners (female = 15; male= 17) in BM class. Classes were taught by the same instructor, who maintained the same teaching style, offered the same instructional materials to learners, and used the same teaching guidance for each class, except the material were shown in different modalities.

The data collection and analysis of sub study 3 consists of two stages, which containing four phases in every stage. The first is the identification of programming profiles of block-based and text-based modalities, using the data captured from Code4all platform (self-constructed). From dimension of code editing, debugging and time interval, phase 1 will analyze the average number of code line edited between each click on "debug", the average number of line changes within the source code between two "debug", the number of "debug" made by a student, the percentage of debugging that have syntactical errors (i.e., that cannot be executed), the percentage of debugging that have same syntactical errors (i.e., that cannot be executed) and the average time spent between two times of "debug". Combining above mentioned data, this study try to discover different programming clusters through K-means clustering method. Phase 2 refers to the identification of students' behavioral trajectories of two programming modalities with data from screen-running video. Using clusters identified from phase 1, here we aim to discover the detailed programming behavior trajectories of students in two programming modalities, and sequential analysis will be applied to reveal the behavior differences. Phase 3 is about the identification of influential factors on two programming modalities, which including demographic features, programming attitudes and programming background. Phase 4 is designed to combine additional data source, including pre- and post- programming knowledge test, final programming project data, interview data, as well as attitude data.

4. Current milestone of the research

4.1 Sub study 1 – learner-centered unplugged programming vs instructor-directed lecturing

The results of sub study 1 revealed discrepancies between two instructional modes. First, learners in the unplugged programming class achieved significantly higher scores on the programming knowledge assessment, compared to learners in the traditional lecturing class. Second, consistent with previous research results (Hsu & Liang, 2021), compared to the traditional lecturing class, learners in the unplugged programming class had higher test scores of the computational thinking skills, particularly on the cooperativity dimension (t (62) = -2.11, p = .04). Next, discrepancies of in-class behaviors showed that the typical behaviors in unplugged programming class was listening to the instructor's instructions and discussion with peers (with the help of participating in unplugged programing activities), while learners in the instructor-directed lecturing class had more behaviors in listening to instructor, taking notes and irrelevant behaviors. Learner attitudes showed a significant difference in the confidence dimension between two instructional modes: learners in the unplugged programming activities self-reported a higher level of confidence than learners in the traditional class. Qualitative analysis of interview data also confirmed those quantitative results. Echoing with previous studies (Brackmann et al., 2017; del Olmo-Muñoz et al., 2020; Price & Barnes, 2015), this research revealed that the learner-centered unplugged programming had potential to improve learners' programming knowledge, behaviors, and attitudes compared to the traditional instructor-directed lecturing mode.

4.2 Sub study 2 – pair programming for high, middle and low pairs

The results of sub study 2 revealed discrepancies among three pairs during pair programming process: the low ranked pair was identified as a lowly-interactive, socially-unsupportive, and programming-distracted pair; the middle-ranked pair was identified as a highly-interactive, socially-supportive, and process-oriented pair; and the high-ranked pair was identified as an interactive, socially-supportive, and goal-oriented pair. Specifically, the low-ranked pair spent more time on distracted gamifications and social conversations; the middle-ranked pair made more conversations about programming explorations, elaborations and questioning answering; and the high-ranked pair focused more on debugging programming codes to achieve goals without detailed explanations. Moreover, regarding student perceptions, the low-ranked pair perceived a negative, unsupportive learning atmosphere; students in the middle-ranked, process-oriented pair perceived a supportive and encouraging collaborative learning atmosphere; the high-ranked, goal-oriented pair perceived a contrasting feeling about the collaboration. Echoing previous studies (e.g., Hwang et al., 2012; Wu et al., 2019; Yang et al., 2015), this research reveals complex correlations between programming behaviors, discourses, and perceptions, which may have significant influences on the collaborative programming quality, performance and experience.

4.2 Sub study 3 –block-based vs text-based programming modality

The preliminary results of sub study 3 revealed the total behavioral features in two modalities, where students in BM showed more amount of features than TM. In particular, students in TM wrote longer lines of codes encountered more syntactical errors and the average time spent between two times of debug in TM were almost twice as long as BM. Besides, students in BM had more average amount of changes of code, spent more time in platform operation, tried more times of debug, and spent more time on irrelevant behavior. Secondly, we modelled students' programming behavior using the behavioral features. Five clusters were identified: operation-focused and programming-balanced cluster, negative coding and debugging-distracted cluster, active coding and debugging-focused cluster, and overall-balanced cluster. In addition, the ANCOVA results revealed that statistically significant differences was identified for programming knowledge (F = 4.43, p < .05, eta^2 = .06), suggesting a middle effect size based on the criteria of Cohen. Students in the BM group outperformed those in the TM group in terms of their programming knowledge performance when learning through different modalities of programming. A series of F-tests were further used to compare five clusters regarding their programming knowledge. It was found that in the text-based modality, the scores of Cluster 2, Cluster 3 and Cluster 5 were significantly higher than Cluster 1.

5. Upcoming work

The future work will focus on the construction of instructional models grounded upon three sub studies.

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華語教師「機器人輔助語言學習」知能培訓之行動研究：以機器人輔助華語正音教學為例

The Action Research of Teacher Training Course Design of Robot-Assisted Language Learning for Chinese as a Second Language teacher: Take Robot-Assisted Chinese Pronunciation Training as an Example

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【摘要】機器人輔助語言學習（robot-assisted language learning, RALL）是科技促進語言學習的新趨勢，而新科技的應用應先從教師培訓出發。本研究目的為提出一個 RALL 培訓課程，培養華語教師整合機器人科技、華語專業及正音教學知識的能力。以行動研究法為主軸，以整合技術的學科教學知識（TAPCK）為框架規劃授課主題、內容與任務，以「設計中學習」為主要策略，並以「體驗與認知-教學設計與程式學習-實作與試測-實測」作為培訓流程；研究對象為 14 名華語教師；在研究過程中，搭配內容分析、調查、訪談法，分析培訓對受訓教師的具體知識發展影響與執行成效，最終提出兼具華語教師所需、培訓理論與成效的 RALL 師資培訓建議。

【關鍵字】機器人輔助語言學習（RALL）；師資培訓（teacher training）；華語文教學（CSL）；整合技術的學科教學知識（TPACK）；教育機器人

Abstract: This study aims to provide a teacher training course of Robot-assisted Language Learning (RALL) based on the Technological Pedagogical Content Knowledge (TPACK) framework for Chinese as a Second Language (CSL) teachers. We used action research to be the methodology and *Quantitative simple count and qualitative c*ontent analysis will applied to analyze the *course effectiveness and the development of teachers' knowledge.*

Keywords: Robot Assisted Language Learning (RALL), teacher training, Chinese as a Second Language (CSL), Technological Pedagogical Content Knowledge (TPACK), Education Robot

1. 研究背景

1.1. 機器人輔助華語學習概況

機器人輔助語言學習（robot-assisted language learning, RALL）是使用機器人來促進人們語言表達或語言技能（聽、說、讀、寫），是科技促進語言學習的新趨勢。RALL 不同於其他的科技工具，至少可提供其他兩項好處：一為學習者可與真實的物理環境互動，並從中學習

語言；二是機器人的外觀通常是人型或動物形狀，兒童和成年人都傾向於將機器人擬人化，相較於其他科技工具可提供使用者一種更自然而真實的互動（van den Berghe et al., 2018）。機器人具有自動化、三維空間實體、重複性、靈活性、數位化、人型外觀、可活動的身體、可交流、擬人化、面對面等特性（Chang, Lee, Chao, Wang, & Chen, 2010），可進行人機互動（Han, 2012; Randall, 2019），其中可交流特性中包含的對話功能，是使用文本轉語音（Text To Speech, TTS）、語音轉文字（Speech To Text, STT）及自然語言處理（Natural Language Processing, NLP）等技術，近年來這些技術進步促進更多機器人的開發及應用，讓機器人輔助語言學習的教學及研究快速發展，也同時促進了對語言習得的了解（Randall, 2019）。

目前 RALL 的研究數量還不多，在 5 本數位科技輔助語言學習的主要國際期刊中（CALL、ReCALL、LLT、CALICO、System），2016 年至今僅有 3 篇文章和 RALL 相關，其中應用於 CSL 領域研究更少，顯示目前機器人應用於華語教學研究仍有缺口，有待更多研究者或教學者投入這個領域，而若要讓更多教學者參與研究，則這些教師需要具備相關知能。

1.2.華語教師機器人輔助語言學習知能師資培訓概況

在語言教學環境中，不同的科技工具將以多種方式影響語言教學的過程及激發更多應用的可能性，最關鍵的是語言教師如何適當且聰明地整合這些技術並應用於教學（Haines, 2015）。Aidinlou, Alemi, Farjami & Makhdoumi（2014）提出機器人應用於英語教學與學習時，語言教師的培訓研究是必要的，他們才是第一線使用者。Cheng, Wang, Yang, Yang & Chen（2021）在實際讓教師參與機器人輔助英語教學設計的研究中，也指出針對學習者與機器人互動設計的教師培訓是開發機器人應用於語言學習時的挑戰之一。

語言教師的科技整合能力可在師資養成過程中培養。師資養成可分為長期的師資教育（teacher education）、短期的師資培訓（teacher training）及師資發展（teacher development）（Waters, 2005）。臺灣目前 CSL 教師師資養成狀況，在長期師資教育中，科技融入的課程佔整體課程比例相對較少（趙安婷，2018）；短期的數位能力師資培訓課程則著重於線上教學能力培養（如鄭琇仁，2015；Lan, Chang & Chen, 2012）；臺灣發表的研究中也還見到針對華語教師 RALL 設計能力培養的師資培訓課程研究，目前 5 本數位科技應用於語言學習的主要期刊中也尚未有針對 RALL 師資培育的文章，此為教育趨勢與實務間的缺口。歷年在教學上應用新科技也有相同的問題，大家都忽略了應先從教師培訓角度出發。

2. 研究目的、問題與範圍

有鑑於上述目前機器人應用於華語教學研究仍有缺口、華語教師的機器人科技應用能力師資培訓仍不足，本研究基於此背景提出一套讓華語教師培養機器人科技應用於華語教學與設計能力的師資培訓課程，目的為透過培訓課程讓華語教師認識目前機器人科技、能利用機器人特性設計合適之教學活動，並能藉由目前機器人提供之程式編寫功能實作出華語教學課程讓華語學習者使用。受訓教師應具備有基本華語教學能力的基礎，如華語本體知識及華語教學法知識，另外由於涉及課程設計及程式編寫適合採長期培訓模式。

Mishra & Koehler（2006）認為資訊時代教師的知識能力是學科內容（Content）、教學（pedagogy）、科技（Technology）知識的整合，認為科技不應該與教學和學科專業知識分開討論，提出「整合技術的學科教學知識」（Technological Pedagogical Content Knowledge，簡

稱 TPACK）框架，讓教師思考「科技」和「教學」與「學科內容」知識的融合與其交互關係，因此本研究以 TAPCK 為框架建構授課主題、內容與任務。培訓課程中，RALL 教學內容部份，目前許多研究使用機器人對話功能和類人的動作設計活動，但卻很少機器人應用於正音教學的研究，另外對話功能用到了 STT、TTS 功能，其中如何善用 STT 技術來進行學生的發音辨識是基礎卻重要的知識，因此本研究培訓內容聚焦在以讓教師具備利用機器人科技設計輔助華語正音之教學為主；RALL 教學對象部分，根據 CSL 學習者以成人居多的趨勢設定為成人。

研究問題如下：

(1)針對華語教師「機器人輔助華語正音教學」培訓中，應教授的知識及培訓策略、流程為何？

(2)培訓過程對受訓之華語教師的具體知識發展與影響為何？

(3)機器人輔助華語教學系統設計應注意之處及教師對機器人輔助華語學習的看法為何？

3. 研究方法

3.1. 研究對象

師資培訓對象以 14 位華語文教學系的碩士生作為研究對象，皆具備華語教學經驗，為現任華語教師或待業華語教師。其中本國籍 10 人、印尼籍 3 人、比利時籍 1 人；性別為 11 女、3 男、年齡為 23 至 53 歲；10 人未曾使用過實體機器人；11 人未曾學過程式設計。

3.2. 研究方法

本研究核心為行動研究法。行動研究（Action Research）法是基於 Kemmis 與 McTaggart（1988）所定義的研究方法，有利釐清教育或教學領域的相關研究議題，並剖析其轉變與改善。研究依序進行規劃、執行、觀察、反思等研究程序，並根據行動研究的理論，交互對比受訓教師的各項反饋。研究流程及研究工具如下圖 1。

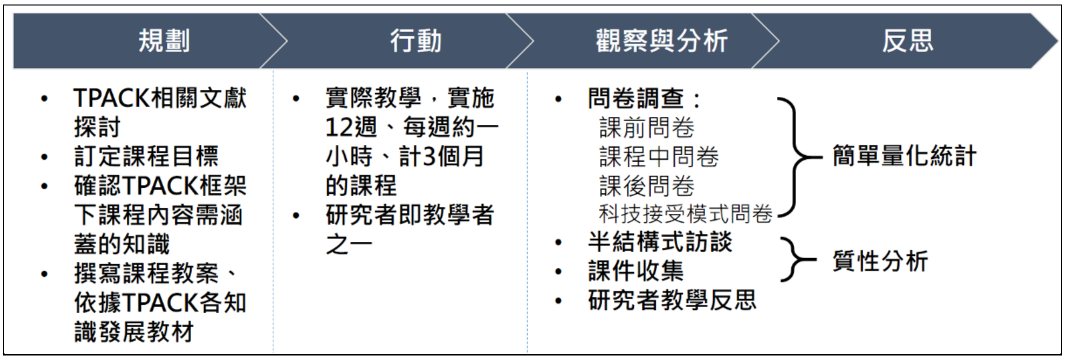

圖 1 本研究的研究流程

4. 現在的研究階段

4.1. 規劃

4.1.1. 培訓設計

(1)教學目標與教學內容：本培訓的教學內容為機器人輔助華語正音教學，正音流程（包含活動、內容）及系統由受訓教師自行設計並實作。

(2)課程師資：由 2 位教師組成本培訓課程師資，一為研究者，一為華語語音專長教師。

(3)RALL 教學對象：教師設計的機器人正音教學對象為在臺灣華語為二語的成人學習者。

(4)機器人角色設定：導師（tutor）或助教，以便讓受訓教師更容易將教學經驗轉換。

4.1.2. 整合技術的學科教學知識（TPACK）概念架構應用於華語正音教學規畫

TPACK 是教師知識的框架，可以協助規畫教師專業發展或課程，可以分析教師所需要了解的技術、教學法、內容及其相互關係的知識。TPACK 包含三大要素（學科內容知識、教學知識、科技知識）及其交集的四種邊界知識，本研究所需的相關知識如下：

(1)學科內容知識（Content Knowledge, CK）：各學門的專業知識。本研究指的是本研究著重 CSL 學生普遍的華語發音問題，以及不同國籍的華語學習者發音難點和常見偏誤。

(2)教學知識（Pedagogical Knowledge, PK）：指學科間共通的教學原理與原則。本研究部份有如何使用教學活動、教學語言、回應及動作引起學生興趣、練習的次數等。

(3)科技知識（Technological Knowledge, TK）：指對數位產物的了解。本研究指的是了解人工智慧在語言上的應用、機器人語音辨識基礎原理（STT、TTS）及機器人程式設計與運算思維的能力。

(4)專門學科的教學法知識（Pedagogical Content Knowledge, PCK）：教學法的策略與語音教學內容的搭配，本研究指的是華語正音的教學法知識，如針對各種發音偏誤的正音技巧，以及華語正音教學法及常使用策略—最小對比（如：/b/-/p/、胖-棒）等。

(5)整合科技的學科內容知識（Technological Content Knowledge, TCK）：指了解學科內容與科技產品相互之間的關係，本研究指的是機器人知識與華語知識的整合應用，如：機器人對話功能中，華語 STT 優先詞選擇機制、機器人目前辨識華語語音問題（單音節詞不易辨識）；以及利用程式編寫華語辨識功能時應注意的地方，如同音詞辨識。

(6)整合科技的教學法知識（Technological Pedagogical Knowledge, TPK）：指知道這些數位科技如何應用於教學與結果，並能針對不同教學法挑選適合的科技產品。本研究指的是使用機器人進行教學時適切的教學策略的使用與搭配，如應用人型機器人教學時可善用其肢體可動性及重複性設計重複練習活動、設計人機互動時應注意之處；以及在程式設計教學活動時常用演算法有哪些，並設計華語教學任務作為程式學習的練習。

(7)整合技術的學科教學法知識（Technological Pedagogical Content Knowledge, TPACK）：是教學、內容與科技三項元素重疊的結果，針對特定學科能夠融合教學策略與數位科技，並知道學生的學習難易處，也了解數位科技能否協助學生的學習難點，或如何應用或設計數位科技協助教學。在本研究中，教師需整合各種知識實作 RALL 正音教學。

4.1.3. 培訓策略

Koehler 和 Mishra（2005a, 2005b）以「設計中學習（learning-by-design, LBD）」策略發展 TPACK 課程，除了知識學習外，教師在設計用於教學目的的科技產品時，可整合應用有關的內容及教學法的先備知識，並在科技的融入中，重新思索、建構和重新解釋以往的知識與經驗；在其他華語教師的數位應用能力課程上，也可看到師傅教師（mentor）具有重要影響力（鄭琇仁，2015），反思學習與同儕協同學習具效果（宋如瑜，2008；Lan, Chang & Chen, 2012）；透過實踐及實際觀察實踐過程的經驗（宋如瑜，2008），教師能意識到設想

中的教學和學生實際使用的差距。因此本培訓以 LBD 為主軸，再融入師傅教師教學與回饋、同儕分組、實習（測）、反思作為策略。

4.1.4. 培訓流程步驟

培訓流程規劃分為四階段：(1)機器人相關科技技術體驗與認知（Experiencing）、(2)機器人正音教學設計（Design）、(3)RALL 程式實作與試測（Production）、(4)華語學習者實測（Implementation），各階段目標、詳細步驟如表 1，其中(2)、(3)、(4)是循環學習修正的過程。

表 1 華語教師「機器人輔助學習」培訓流程

階段	目標	步驟及活動	知能	時間
(1) 機器人相關科技體驗與認知（Experiencing）	對人工智慧、機器人、語音辨識認知與體驗，提供華語教師利用語音辨識技術進行設計思考的基礎	・人工智慧應用程式體驗（Google 塗鴉：認識機器學習） ・電腦語音相關知識 ・STT、TTS 軟體體驗 ・雅婷語音體驗 ・語音助理應用於語言教學 ・機器人科技 ・機器人、RALL 系統體驗	TK TK→TCK TK→TPK	2 週 + 課後
(2) 機器人正音教學設計與機器人程式設計（Design and Programming）	能運用機器人特性進行教學設計、利用語音辨識特性設計語音教學內容	・正音教學：聽辨、跟讀、最小對比 ・找出適合機器人語音辨識的最小對比詞 ・設計機器人教案 ・教案拆解為流程圖	PCK TCK TK→TPK	1 週 + 課後
	能學會用機器人程式設計平台及拼圖式程式進行機器人教學設計	・機器人程式設計教學 ・風格化的機器人回應實作 ・跟讀練習實作 ・機器人打招呼對話實作	TK→TPK TK→TCK	3 週 + 課後
(3) RALL 程式實作與試測（Production and test）	製作機器人語言教學課程雛型、試測及修正	・機器人語言教學課程實作 ・測試 ・修正機器人教案	TPACK	4 週 + 課後
(4) 華語學習者實測（Implementation）	實際應用了解學習者對 RALL 的看法	・華語學習者實測 ・修正機器人教學內容 ・再次實測	TPACK	2 週 + 課後

4.2. 接下來的工作

目前已完成第一輪的執行培訓實踐，包含觀察、紀錄及收集資料。接下來將分析在培訓過程中收集的教師課件、反思報告、成果報告，以了解培訓過程中教師知識的發展及與培訓內容的關聯，也釐清教師在設計機器人輔助語音學習時必備的教學知識與能力；分析問卷及訪談內容，作為培訓流程的修正意見；整理華語教師對 RALL 系統設計提出的注意事項、對目前 RALL 的看法，作為之後發展機器人輔助華語學習系統及課程時的參考。

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