UNIVERSITI PUTRA MALAYSIA

EFFECT OF SERVICE LEARNING MODULE FOR TEACHING ARTIFICIAL INTELLIGENCE ON PRE-SERVICE TEACHERS' PRACTICAL KNOWLEDGE AND MOTIVATION AND STUDENTS' ATTITUDES

SONG PU

FPP 2022 25

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By

SONG PU

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

October 2021

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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October 2021

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Many universities and schools in China attempted to introduce artificial intelligence (AI) subjects in pre-service teachers' (PSTs) training and primary school students' education. It was observed that the traditional PSTs' training modules were not entirely successful in improving their practical knowledge and motivation as well as their students' attitudes toward AI. In particular, PSTs' practical knowledge was very limited, and they were less motivated to teach with the assistance of AI. It was also found that primary school students' attitudes toward AI declined as they grew older. Hence, further studies on new AI training modules or interventions very important. The objective of this study is to develop a service-learning module for PSTs teaching AI subjects using Design and Development Research (DDR) approach. It is designed to examine the effects of service-learning module on PSTs' practical knowledge and motivation in relation to AI as well as to explore primary school students' attitudes toward AI in China.

In order to examine the module's effects on the target group mentioned prior, experimental research was carried out in which the research conformed to the quasi-experimental non-randomised pre-test and post-test control group design. A questionnaire was devised in order to obtain data regarding the pre-service teachers' (PSTs) practical knowledge and motivation, and primary school students' attitudes in determining the effects of service-learning module. For this purpose, the experimental group was subjected to the service-learning module intervention, whereas the control group was taught using the educational practice training module (traditional module) as per routine in their normal classrooms. Participants in this study were 60 PSTs (12 males and 48 females) and 107 primary school students in grade six (50 males and 57 females). The pre-service teachers (PSTs) were divided into experimental and control group, in which the

same was applicable for the primary school students. AI subjects were taught by the pre-service teachers (PSTs) in both groups in which the students were assigned to respectively.

Tests were run in order to guarantee the validity and reliability of the questionnaire being used in this research project. Additionally, due to the target groups being native Chinese, the questionnaire was translated from English to Chinese using the the Brislin back-translation method. Data was collected pre and post intervention. In accordance with the assumptions and conditions of analysis method, paired sample t-test and Wilcoxon's Sign Rank Test were used to investigate the differences between pre-test and post-test, and independent samples t-test and Mann-Whitney U test were conducted to explore the differences between the control group and the experimental group.

This study found that the service-learning module had good content validity based on expert judgement, and the module had a positive effect on the pre-service teachers' (PSTs) practical knowledge and motivation, as well as the primary school students' attitudes toward artificial intelligence (AI) with a score of ($p < 0.05$). Furthermore, the service-learning module was found to be more effective than the traditional educational practice training module in improving the three (psychological) variables mentioned above. Additionally, although the traditional educational practice training module had a positive effect on the PSTs' practical knowledge to a certain extent ($p < 0.05$), it did not significantly improve their motivation and the primary school students' attitudes toward AI ($p > 0.05$).

The findings of this study will contribute to the pre-service teachers' (PSTs) training and the artificial intelligence (AI) course design in primary education, as well as help primary school students better understand AI concepts and improve their attitudes toward it. This study provides valid data, technical support and training methods to improve the PSTs' practical knowledge and motivation in China, and it also provides a platform that combines academic context and skills subsequently merging them into a real teaching situation.

Last but not least, this research provides evidence that using service-learning module improved pre-service teachers' (PSTs) practical knowledge and motivation and primary school students' attitudes toward artificial intelligence (AI) subjects, in line with promoting students' development being a new value orientation of service-learning theory. This research also provides evidence and examples for PSTs training, as well as practical implications on how to improve primary school students' attitudes in the training and learning of AI subjects.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KAJIAN KESAN APLIKASI MODUL PERKHIDMATAN PEMBELAJARAN
KEPINTARAN BUATAN TERHADAP PENGETAHUAN PRAKTIKAL DAN
MOTIVASI GURU PRA-PERKHIDMATAN SERTA SIKAP PELAJAR**

Oleh

SONG PU

Oktober 2021

Pengerusi **:** **Profesor Madya Nor Aniza Ahmad, PhD**
Fakulti **:** **Pengajian Pendidikan**

Adalah didapati kebanyakan universitl dan sekolah di negara China berusaha
memperkenal dan mengadaptasi 'artificial intelligence (AI)'- atau dalam istilah
Bahasa Malaysia 'kepintaran buatan' dalam pendidikan guru pra-perkhidmatan
dan pendidikan sekolah rendah. i Model latihan tradisional didapati tidak berkesan
dalam meningkatkan pengetahuan praktikal kumpulan guru tersebut, motivasi
belajar dan sikap pelajar. Oleh demikian, penyelidikan lebih lanjut mengenai
modul latihan baru atau langkah intervensi adalah sangat diperlukan. Kajian ini
bertujuan untuk mengembangkan modul berasaskan pembelajaran untuk guru
pra-perkhidmatan mengajar AI menggunakan kaedah 'Design and Development
Research' ataupun singkatannya DDR – Reka Bentuk dan Pembangunan
Penyelidikan, seterusnya meneroka impak terhadap pemboleh-ubah ini iaitu
pengetahuan dan motivasi para guru. Kajian ini juga bertujuan untuk menyelidik
sikap pelajar sekolah rendah di China terhadap penggunaan AI dalam
pembelajaran kelas. Dapatan kajian menggunakan kaedah DDR menunjukkan
bahawa skor terendah adalah 0.92 dan skor tertinggi adalah 1.00 – modul 'service
learning' ataupun pembelajaran perkhidmatan adalah baik. Subjek kajian terdiri
daripada 60 orang guru pra-perkhidmatan (12 lelaki dan 48 perempuan) dan 107
pelajar kelas enam (50 lelaki dan 57 perempuan). Eksperimen ini dibahagikan
kepada kumpulan eksperimen dan kumpulan kawalan; terdiri daripada guru pra-
perkhidmatan dan pelajar.

Kajian ini selari dengan reka bentuk kumpulan kawalan pra-ujian dan pasca-ujian
berasaskan kuasi eksperimen bukan rawak. Kaedah tinjauan soal-selidik
digunakan untuk mengkaji pengetahuan praktikal, motivasi dan sikap pelajar
dalam 'service learning' – pembelajaran perkhidmatan bagi menyiasat kesan
modul pembelajaran perkhidmatan tersebut terhadap ketiga-tiga pemboleh-ubah
yang disebut di atas. Untuk tujuan ini, kumpulan eksperimen menerima modul

intervensi berdasarkan 'service learning' – pembelajaran perkhidmatan, sementara kumpulan kawalan menggunakan modul latihan pendidikan tradisional seperti kebiasaan yang dipraktikkan dalam pembelajaran standard. Seterusnya untuk menambah nilai sahih dan kebolehpercayaan soal selidik, kaedah 'back-translation' – terjemahan terbalik Brislin digunakan oleh penyelidik

Data tinjauan telah dikumpulkan sebelum dan selepas intervensi. Menggunakan kaedah andaian dan analisis, ujian t-paired-sample dan Wilcoxon sign-rank digunakan untuk menyiasat perbezaan antara pra-ujian dan pasca-ujian manakala ujian t sampel bebas dan Mann-Whitney U digunakan untuk mengkaji perbezaan antara kumpulan eksperimen dan kumpulan kawalan.

Selepas analisis data, beberapa dapatan dapat disimpulkan seperti berikut: 1) Modul 'service learning' – pembelajaran perkhidmatan memberi kesan positif terhadap pengetahuan praktikal dan motivasi kepintaran buatan atau 'artificial intelligence' (AI) guru pra-perkhidmatan serta sikap pelajar sekolah rendah (p <0.05; terhadap AI 2) Walaupun modul latihan pendidikan tradisional guru pra-perkhidmatan mempunyai kesan positif tertentu (p <0.05), namun didapati tiada peningkatan yang signifikan dikalangan pelajar sekolah rendah berkaitan motivasi belajar dan sikap mereka terhadap AI (p> 0.05). Modul 'service learning' – pembelajaran perkhidmatan mencatat keputusan lebih baik dan secara keseluruhan ia dapat meningkatkan pengetahuan praktikal, motivasi dan sikap pelajar sekolah rendah secara berkesan (p <0.05).

Oleh demikian, kajian ini membuktikan bahawa penggunaan modul 'service-learning' – pembelajaran perkhidmatan meningkatkan pengetahuan dan motivasi praktikal dalam kalangan guru pra-perkhidmatan. Sikap pelajar sekolah rendah terhadap subjek kepintaran buatan 'artificial intelligence' (AI) juga menunjukkan peningkatan yang mana ianya memberi ruang untuk orientasi nilai baru teori 'service learning'. Seterusnya, kajian ini juga menawarkan bukti dan contoh penambahbaikan latihan pendidikan pra-perkhidmatan, serta implikasi praktikal tentang bagaimana sikap pelajar sekolah rendah terhadapm latihan dan pembelajaran mata pelajaran kepintaran buatan 'artificial intelligence' (AI) dapat ditingkatkan.

ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who helped me and brought my research to this stage. My sincere appreciation is to my supportive supervisor, Associate Prof. Dr. Nor Aniza Ahmad, for her constant encouragement and guidance. She has walked me through all the stages of the writing of this thesis. Without his consistent and illuminating instruction, this thesis could not have reached its present form. Her willingness to help has inspired and motivated me tremendously to work harder on this research.

I also would like to express my heartfelt gratitude to Dr. Mas Nida Md. Khambari for her valuable guidance, and contributing with her valuable expertise and knowledge to make this research even better. Moreover, I am greatly indebted to Dr. Ng Keng Yap who has been very generous with his time and never hesitated to share his stupendous knowledge and expertise in the artificial intelligence education. My millions of thanks are to all my friends and every person who have been source of support and encouraging during my research. Also, I will like to extend my sincere gratitude to my colleagues and friends at Universiti Putra Malaysia, especially Wei Mun Chen and Sahar Mohammed Taresh.

Last my thanks would go to my beloved family for their loving considerations and great confidence in me all through these years. Their constant encouragement and unconditional tolerance and considerate companion are the most powerful emotional anchor for me to complete my study. I also express my gratefulness to my beloved parents for their unhesitating support.

Song Pu

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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This is to confirm that:
- the research conducted and the writing of this thesis was under our supervision;
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PSTs	Pre-service teachers
AI	Artificial intelligence
CPC	Communist Party of China
STEM	Science, technology, engineering, mathematics
DDR	design and development research
AAAI	Association for Artificial Intelligence
CSTA	Computer Science Teachers Association
K-S	Kolmogorov-Smirnov

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter begins by providing a background of this study and the problem statement of pre-service teachers' (PSTs) training in teaching artificial intelligence (AI) subjects, subsequently followed by research objectives, research hypothesis, research significance and research scope. And in the end, the definitions of related terms and the summary of this chapter will be concluded.

1.2 Research Background

The artificial intelligence (AI) teacher training has become a new research topic. Improving the pre-service teachers' (PSTs) practical knowledge and motivation, and the attitudes of primary school students toward AI are the most important issues at present. In particular, according to Sales' (2019) research, AI will be the basis for the internet usage in people's everyday lives – it is the future in autonomous driving, robotics, intelligent production and so on. Soon enough, most jobs will become related to AI. This is due to the fact that AI is becoming the basis of all products, where our future wealth will be built on (Kandlhofer et al., 2016). With this progress, the industry that will be influenced mostly is education, especially in the PSTs' education, which focuses on how to train PSTs in imparting knowledge using AI to primary school students.

Even though training the teachers to teach artificial intelligence (AI) subjects to primary school students is a relatively emerging area of research, it has rapidly become a highly important subject area due to the integration of AI and education, and the national policies in various countries (Kandlhofer et al., 2016). In the past 20 years, the advancement of AI technology in education has been significantly influenced by the wave of big data and machine learning. Since AI is highly inclusive, complex and diverse, its impact on education is much more extensive and deeper as compared to other information technology (Roll & Wylie, 2016). After 20 years, the integration of AI and education serves as a research boom because of high demand as well as national policies (Jabłońska & Zajdel, 2018). Therefore, it can be predicted that an inevitable change in the training approach for teachers and their students will challenge current traditional structures by generating new theories, problems, concepts, ideas, and methods.

In the context of China, the government had issued three important education policies to encourage teachers to teach artificial intelligence (AI) to primary school students. In November 2017, the Communist Party of China (CPC) central

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committee and state council published a new policy of "*Opinions on Comprehensively Deepening the Construction and Reform of the Teaching Staff in the New Era", which* proposed that teachers should actively adapt to new technological changes, such as AI and educational technology. In the same year, the State Council issued the "*New Generation Artificial Intelligence Development Plan*" which clearly stated that AI science activities should be widely carried out in primary and secondary schools, and AI-related courses should be set up in primary and secondary schools to gradually promote programming education.

However, under the background of the continuous expansion of artificial intelligence (AI) market and the deepening of its application, AI education is facing a serious shortage of teachers, especially the lack of AI education teachers in primary and secondary schools, kindergartens, vocational education and special education (Guilherme, 2017; Sales, 2019), which has a significantly negative impact on the development of AI education in China in the future. It is urgent to cultivate AI education of pre-service teachers (PSTs) through suitable and reasonable training modules in normal universities (Song & Li, 2021). Therefore, in 2018, the Ministry of Education of China issued the "*Innovation Action Plan for Artificial Intelligence in Higher Education Institutions*" which emphasises the need to improve the AI education teachers training module, and further proposes to train a large number of teachers and students in AI subject within five years.

It is evident that artificial intelligence (AI) education is popular in China however, there is a serious shortage of professional AI education teachers in China. Data presented that only about 35% of the teachers in primary and secondary schools were qualified for some parts of AI-related courses because of their professional background in computer (Liu et al., 2019). This situation highlights the fact that AI pre-service teachers' (PSTs) education training is obviously lagging behind the economic and social development and market demand in the teaching of AI for primary school students.

Currently, China universities have not established artificial intelligence (AI) teacher training programmes and training models for primary and secondary schools (Zhang et al., 2020), resulting in a lack of professional teachers in primary and secondary schools who are knowledgeable about both AI technology and education teaching. In developed regions such as Beijing and Shanghai in China, AI teacher training has not been systematically implemented for pre-service teachers (PSTs) of AI education, although it has been carried out in the form of in-service teacher education, special training, university training, and corporate internships (Xiao, 2020). Additionally, another important aspect is what AI curriculum teachers should develop in primary and secondary schools. China officially launched AI education in primary and secondary schools in 2003, and after more than a decade of educational practice, current AI education mainly involves development in information technology courses, and STEM (science, technology, engineering and mathematics) courses. Although there are AI-related courses on different topics from elementary school, middle school to high school, these courses are fragmented and lack a systematic design in AI interests,

methods, and ability goals. In terms of the age for learning AI knowledge, it is mostly carried out in middle schools and high schools with little involvement in elementary schools (Xie, Cao, & Li, 2019). As for AI curriculum at the elementary school level, some developed regions have made some explorations, for example AI curriculum in elementary school in Beijing focuses on cultivating elementary school students' interest and awareness of AI through perceiving and experiencing AI in life (Ma et al., 2019). The curriculum mainly includes understanding what AI is, experiencing the functions of AI for instance seeing, hearing, speaking, thinking, and moving, and simple manipulative use of graphical programming.

Moreover, research on technology-related subject training for pre-service teachers (PSTs) solely identified 463 articles in the database of *China National Knowledge Infrastructure* over the past 25 years. This indicates that technology-related subject training for PSTs is not yet a major concern among Chinese scholars. Existing researches are only concerned with aspects such as teachers' information technology awareness, knowledge, ethics, ability, etc. Very few of them are in-depth studies on the training of PSTs and their students in artificial intelligence (AI) subjects using experimental research method (Li & Hu, 2016; Zhao, Yan, & Zhu, 2016).

Considerable research had proven that pre-service teachers'(PSTs) practical knowledge is one of the main purposes of teacher training (Balsemão Oss, 2018; Chen, 2003; Elbaz, 1981; Van Driel, Beitar & Verloop, 2001). Mora & Wood (2014) stated a global consensus in their study on teachers' training – that they (the teachers) should be well-trained through practical knowledge of training and learning to use various strategies and should become creative professionals. Practical knowledge is best described as the integrated set of practical wisdom, knowledge, conceptions, beliefs, and insights that underlie teachers' actions in practice (Elbaz, 1981; Lanterman & Applequist, 2018; Van Driel, Beijaard, & Verloop, 2001). Hence, research on the artificial intelligence (AI) education training of PSTs should focus on the development of their practical knowledge, which is practical, personal, and experiential. In the context of China, the course of PSTs training in technology-related disciplines focused on providing PSTs opportunities to participate in real teaching situations, to reflect on their motivation to become teachers, and to generate personal practical knowledge (Yongqin & Shasha, 2020). However, the teaching of practical knowledge in higher normal colleges and universities in China context often adopts the model of students' simulated trial teaching followed by the teacher giving comments. This model seriously hinders normal students from acquiring practical knowledge, because it easily overlooks the connection between theory and practice, students' personal experience, specific educational situations, and the cultivation of reflective ability (Shenghui & Shasha, 2021). Moreover, it limits the studies and practices that are focused on PSTs' AI education. Meanwhile, most past studies made use of qualitative research methods to explore teachers' practical knowledge in the educational context. Limited empirical researches were conducted to examine the relationship between PSTs' training and practical knowledge (Binhui, 2011; Woods & Çakır, 2011).

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As for pre-service teachers' (PSTs) motivation, in China, most of them are trained following guidance and learning control, but they themselves do not comply with the guidance, and may even abandon the profession due to their lack of motivation in professional development. In order to improve the PSTs' motivation, various studies began to focus on the influence of classroom structure, teaching module and teachers' personal factors on motivation (Chigona et al., 2014; Evelein et al., 2008). Meanwhile, China's Ministry of Education issued a document in 2016 entitled '*Emphasis on Improving Teachers' Ability to Teach with Information Technology*' pointing out that teachers' extrinsic motivation can hardly promote teachers' learning enthusiasm, and that there should be more attention dedicated to teachers' intrinsic motivation.

In terms of the relationship between pre-service teachers'(PST) training and motivation, most researches on PSTs' motivation in China mainly focused on professional motivation, teaching motivation, and achievements. Many studies generally proposed that the PSTs' training module should fully consider their motivation towards information technology, due to PSTs should have information technology ability to meet the needs of future education informatisation and the learning needs of children (Tian & Jiao, 2019; Xinhua, 2020; Zembat et al., 2020). Some of them carried out quantitative research on the relationship between technology education in PSTs' training and their motivation (Pan et al., 2005; Zhong et al., 1999). Relevant research results indicated that PSTs lacked the desire to participate in the training, but regarded training as a dispensable activity (Baker & Anderman, 2020). Some PSTs retreated when they encountered difficulties during the training process (Napanoy et al., 2021). Meanwhile, some PSTs did not actively participate in activities even though they participated in learning. Besides that, there were limited studies on the relationship between PSTs' training and motivation towards teaching artificial intelligence – AI (Cho, 2011; Kao-biao, & Yanzhen, 2013).

In China, promoting students' psychological development has become a new trend in the teachers' training module. Previous researches and practice of teacher training did not pay enough attention to the growth and development of students. In contrast, this thesis regards the development and growth of students as the main purpose of teacher training, which is based on the fact that teacher training changes teachers to achieve the ultimate goal of changing students (Mingxi & Yunpeng, 2018). Hence, it is a new perspective to examine the teacher training module. Compared with previous modules of teacher training, the new value orientation emphasises that both teachers and students can mutually benefit.

Furthermore, various studies have proven that improving primary school students' attitude is one of the ultimate goals of pre-service teachers' (PSTs) training. In fact, most studies believed that improving student performance is the key goal of teacher training (Angrist, & Lavy, 2001; Zhang et al., 2013). Improvement in PSTs' knowledge and classroom practices can improve students' attitudes toward a subject (Mccutchen et al., 2002). PSTs should cultivate students' positive attitudes

toward technology because students' attitudes will affect their cognitive development and career choices. Moreover, changes in PSTs' knowledge and classroom practice can improve students' attitudes and outcomes in a training module. In other words, PSTs should transform their knowledge in teaching primary school students. In some instances, even though teachers' training modules might not improve teachers' practical knowledge and motivation, it might indirectly benefit primary school students by improving their learning attitude from the training.

As far as the introduction of artificial intelligence (AI) curriculum in primary schools is concerned, according to the research of Shijun (2006) and Yanjun (2009), improving the attitudes and interests of primary school students and providing them with opportunities to perceive information technology are the main objectives of introducing information technology to primary schools for the first time in China. AI curriculum should provide primary school students with opportunities to perceive AI, with the aim of enhancing their attitudes and interest in it (Kaiquan et al., 2018). Moreover, recent empirical studies showed that the first introduction of AI curriculum in primary schools should follow the steps of basic experience, interest and attitude cultivation, independent inquiry, and professional learning (Wang et al., 2018). Similarly, the research conducted by Gaoyichen et al. (2020) also showed that the initial stage of primary school AI teaching activities is an experiential course, the main goal of which is to cultivate a positive attitude and lay the foundation for future in-depth learning.

In view of students' attitudes toward artificial intelligence (AI)-related subjects, many studies found that students' attitudes toward technology are related to gender, curriculum structure, and teachers' teaching methods (Eisenhart et al., 1996; Gottfried et al., 2009; Hongjia et al., 2014; Zacharia, & Barton, 2004). However, most of these researches focused on students' attitudes toward general computer science, not specifically toward AI. Therefore, there are very limited researches that focused on the students' attitudes toward AI. Hezhong & Wang, (2020) believed that students' attitude towards AI is the pre-requisite for students to form an accurate AI idea, and it is also the guarantee for students to use AI correctly in the AI era. They also argued that the students' primary intelligence literacy includes intelligent attitude, awareness, ethics, knowledge, and skills. At this stage, students do not need to cultivate intelligent thinking and intelligent innovation and form a positive attitude mainly through perceiving AI. A similar point of view comes from Shaojin & Fan (2019); they believed that cultivating students' open and inclusive attitude towards AI is the primary task of AI education, helping students view AI's emergence and development with a positive attitude.

In order to promote pre-service teachers' (PSTs) practical knowledge, motivation, and students' attitude, many researchers introduced the service-learning theory to PSTs' training in the past decade (Al-Khafaji & Morse, 2006; Huband, 2006; Jamieson, 2002; Jawaharlal et al., 2006). Service-learning is a pedagogy or module of experiential education to apply the knowledge or teaching skills PSTs learned in class to real-world problems and real-world needs (Kenworthy-U'Ren

& Peterson. 2005). Therefore, service-learning theory is often developed as a module for teacher education or training.

In China, service-learning module in the teachers' training field is often used to provide teachers opportunities to confront challenges and problems in complex natural contexts and help them gain the practical knowledge and teaching strategies for transferring knowledge and teaching skills to new situations (Gao, 2015). Moreover, one of the main objectives of the service-learning module is to increase technology teachers' motivation by enabling them to design educational activities that cater to the variety of strengths, needs, and interests of students. Service-learning module also focuses on enhancing teachers' positive behaviours such as empathy, educational beliefs, leadership, societal reflection, confidence and so on (Chambers & Lavery, 2012). All these behaviours are positively related to teachers' personal intrinsic motivation.

Additionally, the service-learning theory contends that both pre-service teachers (PSTs) and their students are indispensable beneficiaries in the process of PSTs training. The traditional training module or internship in China only regards PSTs as the main beneficiaries and ignores the necessity of students as the main beneficiaries. As a result, it is difficult for PSTs to understand the meaning of learning, establish educational beliefs, foster a good relationship between teachers and their students and enhance students' interest in learning. And this is despite PSTs and their students both being the stakeholders in the service-learning module for PSTs training.

Last but not least, training pre-service teachers (PSTs) to teach artificial intelligence (AI) subjects has become a highly important subject area. However, research on science and technology in PSTs training is not yet a major concern among Chinese scholars. Many researchers believed that PSTs should be well-trained through practical knowledge of training, and that the internship is the most pivotal period in PSTs training. As for PSTs' motivation, nowadays, most of them are trained under guidance and learning control, but the teachers themselves are seen as refusing such guidance. On the other hand, many studies found that students' attitudes toward technology are related to gender, curriculum structure and teaching methods. However, there are very limited research on students' attitudes toward AI subjects. Hence, this study is expected to develop a service-learning module to promote PSTs' practical knowledge and motivation, and students' attitudes toward AI.

1.3   Problem Statement

Many countries attempted to introduce artificial intelligence (AI) subjects in pre-service teachers' (PSTs) training and primary school students' education; despite AI education being ubiquitous in our daily lives, and the government, society and schools paying more attention to it, the AI education in PSTs training is still limited,

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and introducing AI subjects into primary education is still at the initial stage (Kandlhofer et al., 2016). Therefore, in China, there is a great need for suitable modules that are conducive for the PSTs' training and primary school students to learn AI.

Regardless of having good intentions, the traditional pre-service teachers (PSTs) training modules or projects in China have yet to be effective in improving PSTs' practical knowledge and motivation and their students' attitudes toward artificial intelligence (AI). The content of traditional PSTs training mainly involves the preparation of knowledge in colleges and universities, and the teaching practice in the primary and secondary schools, and finally the test of the practical outcomes The major problem underlying the situation is that the traditional training module may not be addressing the important factors contributing to the three psychological variables (practical knowledge, motivation and attitude). The traditional PSTs' training module, also known as the educational practice training module, was unable to meet the needs of the current development of these teachers (Zhang & Dong, 2020). It is difficult for the trained PSTs to meet the requirements of society and schools for new teachers; the educational practice training module, as a type of traditional internship since the 1950s, has little effect in improving PSTs' practical knowledge or motivation, which makes them unable to be competent for the work of education and teaching for a long time after they were employed (Xiangming, 2018). The reasons for this negative result mainly lie in the poorly-structured teacher training design, which ignores the beneficiary role of primary and middle school students, and lacking sufficient practical experience. For instance, the design of training module in technology-related subjects places more importance on theoretical learning but ignores practical experience i.e., it only pays attention to the benefits of PSTs but neglects the learning outcome of primary school students in the process of the traditional internship. Moreover, the evaluation of PSTs' performance focuses on examination content but ignores the accumulation of practical experience (Jie, 2016, Kan, 2011).

Further to this, the educational practice training module cannot effectively promote pre-service teachers' (PSTs) practical knowledge. In fact, as for educational activities that teach the technology-related subjects, such as computer and artificial intelligence (AI)-related teaching activities, PSTs need more support from practical knowledge, which is action-oriented knowledge, since these teaching activities rely on hands-on activities and practical work to a large extent (Brandes, & Armoni, 2019; Von Hausswolff, 2017). A survey showed that 78% of PSTs lacked practical knowledge (Wenhui et al., 2018). Another study showed that 70% of middle school principals believed that new teachers lacked practical knowledge. In this case, insufficient training of practical knowledge has become a shortcoming restricting the improvement of PSTs' education quality. Therefore, this research is expected to develop a new module (service-learning) to improve PSTs' practical knowledge in AI subjects. However, the effects of such training module on PSTs' practical knowledge still lacks empirical evidence. To bridge this gap, this research provides empirical evidence using quasi-experimental research method.

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Besides practical knowledge, pre-service teachers' (PSTs) motivation also plays an important role in the training module in the technology-related subjects, especially for artificial intelligence (AI) subjects. However, this was not the case in China, whereby most of the PSTs in the university were found to be not highly motivated. Developing PSTs' positive motivation towards technology is problematic in China because some PSTs are not interested in technology (Xiaoyan & LeiXiao, 2014). A survey study showed that PSTs have less motivation to teach technology-related subjects, 90% of them are not interested in relevant theories, and 61% of PSTs believed that teachers' work in the future will not be relevant to technology (Xiaoyan & LeiXiao, 2014). Most of the PSTs are less motivated to teach technology because they do not have sufficient knowledge preparation, awareness of the importance of technical knowledge, confidence to teach technology to children, or sufficient skills in using technology in the traditional training module (the educational practice training module). An existing research gap is that currently there is not much research on the service-learning module or PSTs' motivation towards teaching AI subjects. Therefore, this research aims to examine the effects of service-learning module on PSTs' motivation towards teaching AI subjects.

As afore-mentioned, based on service-learning theory, this study also concerns students' attitudes toward artificial intelligence (AI). In China, the current promotion of AI subjects in primary schools is not common yet, therefore this research focuses on attitude investigations. Various researches in China have proven that students' positive attitude towards technology declines as they grow older (Shi & Feng, 2018). In fact, even students' attitude in primary schools towards technology are declining (Huang, 2017). According to an empirical study conducted by Yi and Xiaoyu (2020), only 60.3% of sixth-grade primary school students have a positive attitude towards technology. In the context of China, primary school students are interested in technology and science itself but lose their interest in 'Technology and Science' as an academic course.

The main reason for the decline in students' attitudes toward technology-related subjects may be attributed to the lack of attention to the learning effects and outcomes of primary school students and their role as main beneficiaries in the educational practice training module. In turn, the design and implementation of the educational practice training module cannot meet the learning needs of primary school students. For example, most technology and science courses do not relate to primary school students' real lives (Ardies et al., 2015 a,b,c). Although primary school students learn technology in class through various activities, what they learn in the classroom cannot be flexibly applied to life. The inability to apply their knowledge causes many students to lose interest in being scientifically literate person. Moreover, George (2006) found that the design and type of training programme might cause the decline of primary school students' positive attitude. Moreover, some researchers pointed out that the decline of students' attitudes is due to the normal differentiation of interest which occurs during adolescence (Krapp, & Prenzel, 2011).

Through the above-mentioned discussion, it is believed that primary school students' real lives and experience are the essential factors which need to be considered in the teacher training design of technology-related subjects in enhancing students' attitudes. However, these factors have been neglected in the design process of the training module, which significantly lead to the decline of primary school students' attitudes toward technology. In order to narrow such gap, this research expects to develop a service-leaning module and examines its effects on primary school students' attitudes toward artificial intelligence (AI).

To address these problems, the researcher aims to develop a service-learning module in training pre-service teachers (PSTs) to teach artificial intelligence (AI) subjects to primary school students. Service-learning module is a method or pedagogy of experiential education to apply the knowledge or teaching skills PSTs learned in class to real-world problems and real-world needs (Kenworthy-U'Ren, & Peterson. 2005). From a theoretical perspective, service-learning module can overcome the drawbacks brought by the educational practice training module (traditional module). This is because the module mainly emphasises four aspects; the integration of theoretical knowledge and practical experience, the beneficiaries including both PSTs and students, the reflection in action and the understanding of the meaning of learning. At present however, the service-learning module has not been developed in AI subjects for PSTs and primary school students. Therefore, in order to fill this research gap, the first purpose is to develop a service-learning module to train PSTs to teach AI subjects for primary school students. Additionally, this research is expected to examine the effects of service-learning module on PSTs' practical knowledge and motivation, as well as students' attitudes toward AI subjects.

1.4 Research Objectives

1.4.1 General Objectives

The general objective of this study is to develop a service-learning module to train pre-service teachers (PSTs) in teaching artificial intelligence (AI) subjects to primary school students, as well as to examine the effects of service-learning module on PSTs' practical knowledge and motivation. Additionally, since PSTs conducted the service-learning in primary school to improve students' attitude towards AI subjects therefore, this study was also carried out to examine the effects of service-learning module on students' attitudes toward AI subjects.

1.4.2   Specific Objectives

This study aims to achieve the following objectives:

1. To develop a service-learning module training for pre-service teachers (PSTs) in the teaching of artificial intelligence (AI) subjects to primary school students

2. To determine the effects of the service-learning module intervention on PSTs' practical knowledge

3. To determine the effects of the service-learning module intervention on PSTs' motivation towards AI

4. To determine the effects of service-learning module intervention on primary school students' attitudes toward AI subjects

1.5   Hypotheses

Objective 2

To determine the effects of the service-learning module intervention on pre-service teachers' (PSTs) practical knowledge.

Hypotheses 1

H1 (a): There are no significant differences in PSTs' practical knowledge between the experimental and control group before the intervention.

H1 (b): There are no significant differences in PSTs' practical knowledge between the pre-test and post-test in the control group.

H1 ©: There are no significant differences in PSTs' practical knowledge between the pre-test and post-test in the experimental group.

H1 (d): There are no significant differences in PSTs' practical knowledge between the experimental and control group in the post-test.

Objective 3

To determine the effects of the service-learning module intervention on pre-service teachers' (PSTs) motivation towards artificial intelligence (AI).
Hypotheses 2

H2 (a): There are no significant differences in PSTs' motivation between the experimental and control group before the intervention.

H2 (b): There are no significant differences in PSTs' motivation between the pre-test and post-test in the control group.

H2 (c): There are no significant differences in PSTs' motivation between the pre-test and post-test in the experimental group.

H2 (d): There are no significant differences in PSTs' motivation between the experimental and control group in the post-test.

Objective 4

To determine the effects of service-learning module intervention on students' attitudes toward artificial intelligence (AI) subjects.

Hypotheses 3

H3 (a): There are no significant differences in the primary school students' attitudes between the experimental and control group before the intervention.

H3 (b): There are no significant differences in the primary school students' attitudes between the pre-test and post-test in the control group.

H3 (c): There are no significant differences in the primary school students' attitudes between the pre-test and post-test in the experimental group.

H3 (d): There are no significant differences in the primary school students' attitudes between the experimental and control group in the post-test.

1.6   Research Significance

The significance of this study is mainly manifested in four aspects; first of all, most of the previous studies on service-learning module in pre-service teachers (PSTs) training focused on computer science instead of artificial intelligence (AI), thus the service-learning module for AI education in PSTs' training is quite new and limited. This research attempts to develop a service-learning module in order to train PSTs teaching AI subjects to improve their practical knowledge and motivation, subsequently they (the PSTs) conduct service-learning in primary school to improve the students' attitudes toward AI subjects. The module developed in this research will also provide valuable information for university teacher educators and primary school teachers in understanding the rationale and need for using service-learning modules in AI education of PSTs' training, developing AI curriculum, and understanding relevant principles, content, tools and teaching strategies. All the above, and ultimately, the service-learning module is aimed to provide PSTs a platform that combines academic context and skills based on real teaching situations.

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Secondly, this research was able to develop and verify the application effects of service-learning module in pre-service teachers' (PSTs) training and student-learning of artificial intelligence (AI) based on Design and Development Research (DDR) and quasi-experimental research methods. The research results provided empirical evidence to prove that the service-learning module has a positive effect on PSTs' practical knowledge, motivation as well as primary school students' attitudes toward AI. Furthermore, this research had contributed to explaining why the module had a positive effect – such contribution will help policymakers, university teachers and primary school teachers to understand the principles, favourable factors, concepts, procedure and training strategies that need to be accounted for in the development of service-learning module, as well as help them develop new modules according to their own teaching situations.

Last but not least, very limited studies have been conducted on the development of service-learning module for the pre-service teachers' (PSTs) training and students learning in artificial intelligence (AI) subjects (Joon-fei., 2011; Kao-biao & Yanzhen., 2013). In contrast, this research did not only demonstrate the development design components of the service-learning module, which included training principles objectives, content, tools, and process but also verified that the module had a positive effect on the PSTs' practical knowledge, motivation, and primary school students' attitude towards AI subjects in the process of the module implementation. In this case, the findings of this research provided valid data, development design components and training methods to improve PSTs' practical knowledge and motivation in the teaching of AI in China. Besides that, this research also helps university teacher educators and managers to understand what factors contribute most to the development of PSTs' practical knowledge and motivation in the service-learning module implementation.

Finally, it should be noted that previous studies focused on students' attitudes toward computer science, but not on artificial intelligence (AI) (Barmby et al., 2008; Gottfried et al., 2009; Venturini, 2004). In other words, research on well-structured AI courses to enhance students' attitudes are extremely limited. Hence, improving students' attitude towards AI is an important goal of the module development in this research. The conclusions of the module development will contribute to the AI course design in primary education for primary school teachers and managers. This study would also help primary school students grasp a better appreciation of AI concepts and enhance their attitudes toward AI, which will also help primary school teachers and school administrators to introduce AI subjects in their courses, and help them understand how to develop AI courses. Moreover, this study is an on-going work in mainland China, where the service-learning module is used in the training of pre-service teachers (PSTs) in relation to AI education for the first time.

1.7 Research Scope

This research involved two main groups which make the core interest of the study; the first group of participants in this research are sixth-semester students majoring in educational technology from a university in Gui Yang, Guizhou Province of China. All of them are aged between 20 to 21 years old. The second group of participants comprise students between the age of 10 to 12 years old from a primary school in Gui Yang, Guizhou province.

The service-learning module includes six educational activities of preparation, team building, instructional design, implementation, demonstration and reflection. As for the content teaching, the service-learning module in the present study involves five artificial intelligence (AI) concepts; machine-perception, representation and reasoning, machine-learning, natural interaction, and societal impact. This study will examine the effects of service-learning module on pre-service teachers' (PSTs) practical knowledge and motivation toward teaching AI subjects. Additionally, the research is also expected to examine the effects of service-learning module on students' attitudes in the context of the teaching of AI.

It is to be noted that pre-service teachers' (PSTs) practical knowledge includes six components including educational beliefs, situational knowledge, self-knowledge, interpersonal relationship knowledge, teaching strategies knowledge, and self-reflection knowledge. Their motivation consists of intrinsic motivation, extrinsic motivation and amotivation. Meanwhile, primary school students' attitude towards artificial intelligence (AI) subjects consists of career aspirations, interest in AI, tediousness of AI, positive perception of effects of AI, perception of difficulty, and perception of AI as a subject for male and female students.

1.8 Conceptual and Operational Definitions

1.8.1 Artificial Intelligence (AI) Subjects

Conceptual definition:

The term "artificial intelligence" is used to describe machines that mimic "cognitive" functions that humans associate with other human minds, such as "learning" and "problem-solving" (Russell & Norvig, 2009). In computer science, artificial intelligence (AI) is defined as a system's ability to interpret external data correctly, learn from, and use this knowledge to achieve specific goals or tasks through flexible adaptation (Kaplan & Haenlein, 2019).

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Operational definition:

In this study, the operational definition of artificial intelligence (AI) subjects refers to the AI-related curriculum offered in primary schools, whose content involves machine perception, representation and reasoning, machine learning, natural interaction, and societal impact in primary school. Some may prefer a more traditional division into application areas (speech, vision, planning, game playing, natural language, robotics, etc.), but Touretzky et al. (2019) believed that the five aspects mentioned above better meet the needs of K-12 students and teachers.

1.8.2   Service-learning Module

Conceptual definition:

Service-learning is a method or pedagogy of experiential education in which students apply what they learn in class to real-world problems and real-world needs (Kenworthy-U'Ren & Peterson, 2005; Silvovskyet al., 2004).

Operational definition:

In this study, service-learning module developed by the researcher is expected to train the pre-service teachers' (PSTs) practical knowledge and motivation for teaching artificial intelligence (AI) subjects among primary school students which include but not limited to machine perception, representation and reasoning, machine learning, natural interaction, and societal impact. In addition, this study also aims to improve students' attitudes toward AI. The service-learning module provides the PSTs the first practical experience with AI teaching for primary school students. They have the opportunity to apply their knowledge, experience, and ideas into a real teaching context, which will improve their practical wisdom and teaching skills.

1.8.3   Practical Knowledge

Conceptual definition:

It is considered that the integrated set of practical wisdom, knowledge, conceptions, beliefs, and insights support pre-service teachers' (PSTs) actions (Elbaz, 1981; Van Driel et al., 2001). Meanwhile, practical knowledge grows out of practice, circumstances and actions, which simultaneously guides practice (Connelly, & Clandinin, 1985; Pu & Xiang, 2017).

Operational definition:

In this study, practical knowledge is the foundation of the main content of pre-service teachers' (PSTs) professional knowledge. Practical knowledge refers to

the dynamic knowledge system that PSTs construct by themselves, which combines theoretical knowledge with practical experience through problem-solving and reflection in actions. This process also contains the PSTs' educational beliefs, motivation and wisdom. According to Jie (2016), after learning the technology training module, the pre-service teachers (PSTs) will gain their familiar practical knowledge, which includes six components of educational beliefs, situational knowledge, self-knowledge, interpersonal relationship knowledge, teaching strategies knowledge, and self-reflection knowledge. Educational beliefs refer to teachers' understanding about the purposes of artificial intelligence (AI) training, why teachers should participate in the training module, what kind of education students should receive, and the teaching method they would like to use. On the other hand, situational knowledge is teachers' practical pedagogical wisdom acquired through authentic practices or teachers' perceptions and understandings embedded in the training module. Meanwhile, self-knowledge mainly refers to teachers' cognition about the mental representation of themselves, which includes self-teaching efficacy, self-regulation, and self-characteristics (interest, attitude, temperament, ability). Next, interpersonal relationship knowledge refers to the teachers' perception and understanding of students, enthusiasm and passion. Teaching strategies knowledge refers to teachers' application of their subject matter knowledge, as well as pedagogy and educational theory to specific strategies in teaching. Ultimately, self-reflection knowledge is a practice-oriented reflection, which is mainly involved before, during and after the training module.

1.8.4   Motivation towards Artificial Intelligence (AI)

Conceptual definition:

Motivation is closely related to teachers' choice in teaching strategies, in career, and in job involvement (Alexander, 2008). According to the theory of self-determination put forward by Deci et al. (2001), psychological needs that determine individual behaviour are the need for competency, autonomy, and relatedness. Ryan & Deci also identified three types of motivation; intrinsic motivation, extrinsic motivation, and amotivation.

Operational definition:

In this study, the term "motivation" refers to internal and external factors that induce actions. Besides that, motivation is also regarded as a critical factor in understanding pre-service teachers' (PSTs) behaviour in the training process, which is also expected to explain why PSTs will teach artificial intelligence (AI) to primary school students in the future. There are three types of motivation; intrinsic motivation, extrinsic motivation and amotivation. Intrinsic motivation refers to the behaviour that is driven by an individual's interest in the activity itself. In contrast, extrinsic motivation refers to the act of engaging in an activity in order to obtain the external outcome, but not because of personal interest in the activity itself.

Amotivation on the other hand refers to the lack of motivation for self-determination and lack of interest in activities.

1.8.5 Attitude towards Artificial Intelligence (AI)

Conceptual definition:

In educational psychology, attitude is a psychological construct, a mental and emotional entity that inheres in, or 16onceptualize a person (Perloff, 2016), which is expressed through evaluating a particular entity with some degree of favour (Eagly & Chaiken, 1993). The attitude is explicitly 16onceptualized as excluding the cognitive dimension. However, people's knowledge of a certain technical subject may be related to attitude towards the subject (Pearson, 2006).

Operational definition:

In this study, primary school students' attitudes toward artificial intelligence (AI) comprises their collection of beliefs about AI concepts, which also associates with their emotional reactions. The reactions result in stimulation that directly affects decisions regarding AI, such as the choice to undertake a specific AI course, to read about AI and to adopt AI-related hobbies. Components of primary school students' attitudes toward AI subjects include career aspirations, interest in AI, its tediousness, positive perception of its effects, perception of difficulty, and gender perception of AI as a subject. Career aspirations are the primary school students' yearning for an AI career, that is, the tendency of hoping to engage in an AI career. Interest in AI is the attitude and tendency of primary school students to explore it and engage in AI-related activities. The tediousness of AI means that its subjects are uninteresting and boring for primary school students. Positive perception of the effects of AI refers to primary school students' attitude toward its influence of on human life, study and work. Perception of difficulty is the difficulty that primary school students face in learning AI. And finally, the gender perception of AI as a subject refers to the gender differences in its learning.

1.9 Summary

The teaching of artificial intelligence (AI) subjects at primary and secondary school levels hardly exists in many countries (Kandlhofer et al., 2016). Although many countries have tried to introduce AI in their school curriculum, especially at primary and secondary levels, the study of AI education remains limited, especially in the training of AI educational teachers. Meanwhile, most of previous studies on training modules for teachers and their students focused on computer science instead of AI. In that case, it may lead to a severe problem that the traditional training module may not be addressing the most important factors contributing to pre-service teachers' (PSTs) practical knowledge and motivation and their students' attitudes.

Bers & Portsmore (2005) believed that teachers' training should start from pre-service teachers (PSTs) and they further asserted that teachers lacked training and expertise in teaching AI subjects in a constructivist curriculum and method. Hence, to address this issue, this study expects to develop service-learning module training PSTs to teach primary school students AI subjects.

Moreover, to measure the success or failure of the service-learning module, a quasi-experimental study was conducted to examine the effects of service-learning module on pre-service teachers' (PSTs) practical knowledge and motivation. Various researches indicated that teachers' practical knowledge is related to PSTs' training and development (Armoni, 2011; Chen, 2003; Shulman,1987). PSTs training is widely believed to influence teachers' practical knowledge. Through training, PSTs will be able to acquire practical knowledge (Jie, 2015). However, the acquisition of practical knowledge is scarce and limited in the technical training of PSTs in China.

Meanwhile, the motivation of teachers to engage in teaching technology-related subjects is low, and most pre-service teachers (PSTs) are reluctant to become technical teachers or science teachers in primary and secondary schools due to the lack of well-structured training modules in China. Hence, this study aims to investigate the effects of service-learning module on practical knowledge and motivation among PSTs in the Guizhou Province of China. It is expected to use the service-learning module to improve PSTs' practical knowledge and motivation toward artificial intelligence (AI) teaching.

According to the preferred theory (service-learning) in this study, pre-service teachers' (PSTs) training should not only focus on their theoretical learning and knowledge reserve in the university but should also focus on serving primary school students. In fact, most studies believed that the improvement of students' performance is the ultimate goal of teacher training (Angrist & Lavy, 2001; Zhang et al., 2013). Additionally, a common problem in China is that primary school students' learning attitudes toward technology-related subjects are declining with age because of the lack of well-structured courses. Therefore, this study also focuses on the effects of service-learning modules on primary school students' attitudes toward artificial intelligence (AI) subjects.

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