COMPARING THE EFFECTS OF ARTIFICIAL INTELLIGENCE (RAIN CLASSROOM), MATLAB AND MULTIMEDIA TEACHING PLATFORMS IN ENHANCING CONCEPTUAL UNDERSTANDING AND INNOVATIVE THINKING AMONG AUTOMATIC CONTROL PRINCIPLES COURSE UNDERGRADUATES IN CHINA

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

ACP	Automatic Control Principles
AI	Artificial intelligence
ANOVA	Analysis of variance
APOS	Action-Process-Object-Schema
APP	Application
AR/VR	Augmented Reality/Virtual Reality
CAI	Computer-assisted instruction
CSCI	Control Systems Concept Inventory
DTL	Distance e-Teaching and e-Learning
EU	European Union
GOFAI	Good Old- Fashioned Artificial intelligence
IT	Information Technology
ITE	Innovative Thinking in Education
LSD	Least significant difference
MOOC	Massive open online course
MANOVA	Multiple analysis of variance
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
PVTA	Personalized virtual teaching assistant
RQ	Research Questions
STEM	Science, technology, engineering, and mathematics
TA	Thematic analysis
USM	Universiti Sains Malaysia

LIST OF APPENDICES

PERBANDINGAN KESAN PLATFORM PENGAJARAN KECERDASAN BUATAN (RAIN CLASSROOM), MATLAB DAN MULTIMEDIA DALAM MENINGKATKAN KEFAHAMAN KONSEPTUAL DAN PEMIKIRAN INOVATIF DALAM KALANGAN PELAJAR KURSUS SARJANA MUDA *AUTOMATIC CONTROL PRINCIPLES* DI CHINA

ABSTRAK

Kajian ini bertujuan untuk mengkaji kesan platform pengajaran Kecerdasan Buatan (AI: Rain Classroom), Matlab, dan Multimedia serta persepsi pelajar dan guru mereka tentang penggunaan ketiga-tiga platform pengajaran ini dalam meningkatkan kefahaman konseptual dan pemikiran inovatif dalam Kursus Prinsip Kawalan Automatik (ACP). Kajian ini menggunakan reka bentuk kaedah bercampur penjelasan berurutan. Data kuantitatif dikumpulkan menggunakan Inventori Konsep Sistem Kawalan (CSCI) (untuk mengukur pemahaman konseptual pelajar ACP), dan Skala Pemikiran Inovatif dalam Pendidikan (ITE) (untuk mengukur keupayaan pemikiran inovatif pelajar). Dengan menggunakan teknik analisis MANOVA dan ANOVA, dapatan kajian menunjukkan bahawa terdapat perbezaan yang signifikan dalam kefahaman konseptual pelajar tentang ACP dan pemikiran inovatif dalam tiga platform pengajaran yang dikaji. Keputusan menunjukkan bahawa platform pengajaran AI (Rain Classroom) adalah yang terbaik dalam meningkatkan kefahaman konseptual dalam ACP, diikuti oleh platform pengajaran MATLAB dan kemudian platform pengajaran multimedia. Untuk keupayaan pemikiran inovatif, platform pengajaran MATLAB mempunyai kesan terbaik, diikuti oleh platform pengajaran AI (Rain Classroom) dan platform pengajaran multimedia. Data kualitatif yang dikumpulkan daripada temubual (dengan guru dan pelajar) dan semakan dokumen-dokumen yang

berkaitan (buku teks dan spesifikasi kurikulum ACP) bagi mengkaji persepsi pelajar dan guru terhadap penggunaan ketiga-tiga platform pengajaran dalam kursus ACP dianalisis menggunakan teknik analisis tematik. Dapatan menunjukkan bahawa untuk platform pengajaran Kecerdasan Buatan (Rain Classroom), pelajar dan guru bersetuju bahawa ia meningkatkan kefahaman konseptual dan pemikiran inovatif pelajar dalam kursus ACP dengan merangsang interaksi guru-pelajar, pembelajaran berulang, dan pembelajaran secara individu. Bagi platform pengajaran MATLAB, kefahaman konseptual dan pemikiran inovatif pelajar dirangsang apabila kandungan pengajaran abstrak ACP diubah menjadi proses intuitif dan dinamik melalui eksperimen simulasi yang menarik. Platform pengajaran Multimedia, sebaliknya, membantu kefahaman melalui pengajaran kursus, pertukaran maklum balas pertukaran, dan pengintegrasian pengetahuan. Justeru, dapat disimpulkan bahawa platform pengajaran AI (Rain Classroom) dan platform pengajaran MATLAB adalah penting dalam merangsang kefahaman konseptual dan pemikiran inovatif pelajar dalam kursus ACP. Dapatan kajian ini juga boleh dijadikan panduan untuk memperbaiki proses pengajaran dan pembelajaran kursus ACP bagi universiti-universiti di China.

COMPARING THE EFFECTS OF ARTIFICIAL INTELLIGENCE (RAIN CLASSROOM), MATLAB AND MULTIMEDIA TEACHING PLATFORMS IN ENHANCING CONCEPTUAL UNDERSTANDING AND INNOVATIVE THINKING AMONG AUTOMATIC CONTROL PRINCIPLES COURSE UNDERGRADUATES IN CHINA

ABSTRACT

This study aimed to investigate the effects of Artificial Intelligence (AI: Rain Classroom), MATLAB, and Multimedia teaching platforms and the students and their teachers' perception of the use of these three teaching platforms in enhancing students' conceptual understanding and innovative thinking in the Automatic Control Principles (ACP) course. This study used a sequential explanatory mixed methods design. The quantitative data were collected using the Control System Concept Inventory (CSCI) (to measure students' conceptual understanding of ACP), and the Innovative Thinking in Education (ITE) scale (to measure students' innovative thinking ability). Using MANOVA and ANOVA analysis techniques, findings showed that there are significant differences in student's conceptual understanding of ACP and innovative thinking in the three teaching platforms studied. The results showed that the AI (Rain Classroom) teaching platform can best improve students' conceptual understanding of ACP, followed by the MATLAB teaching platform and then the multimedia teaching platform. For innovative thinking ability, the MATLAB teaching platform has the best effect, followed by the AI (Rain Classroom) teaching platform and multimedia teaching platform. The qualitative data collected from interviews (with the teachers and students) and related documents (textbooks and curriculum specification of ACP) to investigate the student's and teachers' perceptions of using the three teaching

platforms in the course of ACP were analyzed using thematic analysis technique. Findings showed that for the Rain Classroom teaching platform, both students and teachers agreed that it improved students' conceptual understanding and innovative thinking in the course of ACP by increasing teacher-student interaction, repeated learning, and individualized learning. For the MATLAB teaching platform, students' conceptual understanding and innovative thinking were promoted when the abstract teaching content of ACP was transformed into an intuitive, dynamic process through interesting simulation experiments. Multimedia teaching platform, on the other hand, helped students understand through course teaching, exchange feedback, and knowledge integration. Thus, it can be concluded that AI (Rain Classroom) teaching platform and MATLAB teaching platform are important in promoting students' conceptual understanding and innovative thinking in the ACP course. The findings of this study can also serve as a guide for the betterment of the teaching and learning process of the ACP course for universities in China.

CHAPTER 1

INTRODUCTION

1.1 Introduction

As a vital means to liberate human productivity, automated control technology has penetrated various fields of human society. The study of the automatic control principles (ACP) course is the general motion law of automatic control systems and the general control method (Dotoli et al., 2019). At the same time, the course ACP is very important in the information technology subject (Wang & Yang, 2020). It is a course with both theory and practice and is highly engineering, comprehensive, methodological, and practical. Therefore, as the basis for the follow-up development of control science, ACP course is not only an important core course for automation specialty but also a core course for all electronic information technology, electrical automation, robot engineering and other related majors.

The course of ACP is theoretically strong, the mathematical derivation is difficult to understand, and concepts are more abstract and complex (Čech et al., 2019). Students need to have solid professional basic knowledge such as advanced mathematics, college physics, circuit analysis, signal and system. At the same time, the course not only contains in-depth theoretical knowledge but also closely relates to practice, with strong practicality (Jianpin & Peng, 2019). In teaching the ACP, teachers can guide students' engineering practice, lay a solid professional foundation for students' further study and development in the future, stimulate students' innovative thinking potential, and cultivate students' problem-solving ability (Zhang et al., 2014, Hairu et al., 2019). However, in the current teaching situation, for students with weak foundations, learning is often tedious and hard to comprehend, which cannot adapt to the course of ACP (Jianpin & Peng, 2019). The willingness of students is not boosted,

which affects the learning efficiency. At the same time, the cultivation of innovative thinking in the ACP course is not good. Improving students' conceptual understanding and innovative thinking ability in the ACP course is a problem many teachers need to solve (Zhang et al., 2014, Tian et al., 2019). The cultivation of conceptual understanding ability and innovative thinking greatly influences students' learning effect the ACP course. Therefore, it is urgent to improve students' conceptual understanding ability in the ACP course and fully exercise students' innovative thinking ability in learning, which is of incredible importance to students' future growth (Jan & Khan, 2021).

With the development and popularization of teaching technology, traditional subject teaching faces new challenges, and teaching platforms and teaching means are diversified. Increasing numbers of teaching platforms are applied to instructing automatic control principles, such as traditional teaching methods, the most widely used multimedia teaching platform, MATLAB teaching platform, and artificial intelligence (AI) teaching platform. With the maturation of AI technology in the past two years, AI education has wrapped the whole chain of teaching, learning, student examination, evaluation, and management and has been accelerated in preschool education, K12, higher education, and online vocational education (Chen et al., 2020). In addition, the development of AI technology has also promoted the diversified development of education, resulting in many new teaching ways (Holmes et al., 2019). In China, many schools have applied AI teaching platforms to the course of ACP. AI technology helps students understand curriculum concepts and improve learning efficiency. The AI teaching platform in this study represents the Rain Classroom teaching platform. Rain Classroom is a teaching platform mainly for the field of higher education. It uses the most portable and effective means to integrate the latest

information technology and AI technology into the teaching scene and is committed to providing digital and intelligent information support for all teaching processes. MATLAB is a numerical analysis software launched by MathWorks in the 1980s, and it is also the best numerical calculation software in the world (Moler, 2018b). The software has become a basic teaching tool for applied algebra, automatic control theory and other courses (Moler & Little, 2020, Wen et al., 2017). The application of the MATLAB teaching platform to the instruction of the ACP has important practical significance in teaching this course and has achieved satisfactory teaching outcomes (Shaozi et al., 2014, Yuebang et al., 2017). The use of the MATLAB teaching platform makes the abstract concept of the course vivid and intuitive to help students understand. Currently, most schools use the multimedia teaching platform for teaching, but the teaching effect is not satisfactory. There are problems in the cultivation of students' innovative thinking abilities. In many cases, it is a one-way lecture, lacking interaction with students, teaching methods are single, and most students are passive learning, lack understanding, thinking and interaction of the course (Krippel et al., 2010).

Facing the characteristics of the ACP course and the current teaching situation, including students' difficulty in understanding the concept of the course, students' conceptual understanding ability needs to be improved, and students' innovative thinking ability is insufficient in the learning. So, teachers must try to use different teaching platforms and improve the problems in instructing the ACP by changing the teaching platform and teaching methods. Therefore, in this study, researcher try to compare the effects of artificial intelligence, MATLAB, and multimedia teaching platform in enhancing students' conceptual understanding and innovative thinking in the ACP and investigate the effects of different teaching platforms on students' conceptual understanding and innovative thinking. Analysis of the use of different

teaching platforms teaching processes is how to make students easy to understand the concepts and how to cultivate students' innovative thinking (Huang & Chan, 2020). It includes how artificial intelligence technology and the MATLA platform affect the teaching and learning of automatic control principles and provides reference and direction for the teaching and learning ACP course in universities.

1.2 Background

Automatic control theory and technology are increasingly widely used in high-tech fields such as industrial production, robot manufacturing and intelligent manufacturing. Automated control technology has been applied to all aspects of people's lives, such as urban management, medical testing, environmental monitoring, etc (Fan & Zhang, 2020). The university's ACP course is to cultivate high-level talents who master modern control engineering and control technology. The field of control engineering with automation as the core technology plays an important role in realizing the growth of national strength, the improvement of the ecological environment and the general improvement of people's living standards (Guo & Zhou, 2022). From large-scale industrial production and advanced manufacturing to supply chain management, intelligent transportation to building automation, and medical instruments to home services, various technologies in the field of automatic control are improving production efficiency and changing our lives more beautifully. The ACP course is one of the most basic and essential courses in automation majors. It is a bridge for exchanging basic knowledge and professional knowledge in the entire professional content (Guozen, 2020). The teaching effect of this course directly affects students' learning outcomes in subsequent professional courses and the construction of their knowledge system. The help of studying the Automatic Control Principles (ACP) is

that this course runs through the general methods and basic thinking methods of scientific research. Therefore, by learning the principle of automatic control, students' scientific research methods and logical thinking abilities can be cultivated. Secondly, this course is an engineering science supported by a complete mathematical system, which is incredible assistance to the improvement of students' practical engineering capacity (Yongle, 2021).

The ACP course has a strong basic theory, abstract course content, and strong practicality, focusing on the close combination of theoretical conceptual understanding and practical innovation (Wei, 2021). Therefore, this course plays a significant role in cultivating students' basic theory and creative thinking ability. It also cultivates students' ability to establish scientific views that integrate theory with practice and improve comprehensive analysis. Because many concepts, abstractions characterize the ACP course and a large proportion of theoretical analysis and mathematical calculations in teaching, if teachers ignore the improvement of teaching concepts, methods, and means, it will make it challenging for students to comprehend the course's concepts and reduce the efficiency of learning. In addition, it is challenging for students to understand the concepts of abstract technological terms (Guozen, 2020). Through the analysis of the test papers of ACP in some colleges and universities, teachers can see that students have encountered many problems in understanding the concepts. According to students' cognitive level, students' understanding of ACP can be divided into four levels: cognitive stage, primary cognitive stage, specific cognitive stage, understanding, and application stage. According to the analysis of the test results of the principle of automatic control in colleges and universities, most students are in the primary cognitive stage, and only a few students can fully understand and practice related concepts for application innovation (Guo, 2011). In the teaching of ACP course,

the teaching content mainly includes three parts of basic concepts, time-domain analysis and frequency domain analysis. In the teaching process of the ACP course, teachers will focus on explaining three parts because these three parts are the core content of the ACP course. When teaching these three parts of the content, teachers will attach great importance to whether students understand the concept of these three parts, which is related to the teaching effect of this course, and whether students master and understand the knowledge of this course. At the same time, students face the most challenges in learning these three parts. Through interviews with students, it can be known that students will encounter some difficult concepts in learning these three parts, do not know how to apply relevant knowledge in practice, and cannot complete after-school exercises (Rong, 2013).

Students' conceptual understanding in the course of ACP implies that students can understand and master the essential meaning of the concepts, principles and laws of the course; be able to systematize and specify the knowledge and concept of the ACP course; can rebuild or adjust the cognitive structure, achieve knowledge integration. In the ACP course, students learn and understand general basic concepts, time-domain analysis concepts and frequency domain analysis concepts, and some of the content will encounter very abstract and difficult to understand the content. It is not easy for students to fully understand; sometimes, they can only understand the elementary meaning (Wang & Yang, 2020). Only by fully understanding and mastering the contents of these parts can better and comprehensively understand the course of the ACP and better apply the knowledge and innovate.

A common problem in teaching the ACP is that the cultivation of students' innovative thinking ability needs to be improved. Based on the ACP course characteristics, this course is essential to cultivate students' innovative thinking. While

teaching, integrating theory with practice, engineering case analysis, and simulation experiments are helpful to cultivate students' innovative thinking and exercise their comprehensive analysis ability (Zengxi et al., 2020).

In China, cultivating innovative talents in higher institutes is an eternal research topic worthy of exploration and study by researchers and teachers (Yufei, et al., 2020). Universities prioritize the cultivation of students' innovative consciousness and innovative thinking ability by cultivating students' innovative ability in the lecture class (Tianxin, 2010). Cultivating students' innovative thinking in the ACP course is an important task. Due to the use of recursive formula derivation and explanation in traditional teaching, it is easy for students to feel profound, boring, and difficult to understand, which will lead to boredom. As a result, students' interest in learning is reduced, and the ability of students to integrate theory with practice cannot be enhanced, which affects the cultivation of students' innovative thinking (Ren & Lan, 2021, Pan & Wu, 2018). Students' innovative thinking refers to the process of cultivating students' thinking to solve problems with novel and original creation methods in learning the ACP course (Lin & Wu, 2016). It manifests in that student can break through the limitations of conventional thinking and think about problems from different perspectives, resulting in a novel, distinctive and innovative result. Cultivating innovative thinking in the ACP course mainly guides students to be problem-oriented, cultivate good innovative literacy and improve innovative thinking in observing, questioning, networking and experimenting. Practical experience is fundamental to developing students' innovative potential and cultivating innovative ability. Only through practical activities such as questioning, observing, networking, and experimenting can students' innovative thinking ability be effectively improved. The importance of innovative thinking for students is reflected in the ability to

maximize their potential and talents, stimulate the initiative of learning and growth, achieve comprehensive development, and at the same time, ensure that students are competitive in future employment.

To improve the teaching effect of ACP, many teachers tried to reform the teaching of ACP course and introduce new teaching technology (Bigeng et al., 2017). With the rapid development of AI technology and its wide application in education. AI, an important driving force leading a new round of scientific and technological revolution and industrial transformation, has spawned a large number of new products, new technologies, new business models and new models. Bring more possibilities for the modernization of education (Yang, 2019). The importance and trend of AI in education are mainly reflected in the transformation of educational ecology. Teaching, practice, assessment, evaluation, and management are all assisted by AI, allowing teachers to teach more efficiently (Alam, 2021); combining virtual reality, multi-scenario teaching, and collaborative education, allowing students to learn better; massive online data and increasingly powerful computing ability to make school management more precise (Xiao et al., 2020). In addition, with the support of AI, high-quality digital education resources are becoming more and more abundant, promoting education to be fairer. Many teachers use AI teaching platforms to teach courses on the ACP, such as the Rain Classroom.

At present, AI (Rain Classroom), MATLAB, and multimedia teaching platforms have also begun to be used to teach ACP (Sheng & Zhu, 2019). The Rain Classroom teaching platform utilizes AI technical advantages to reconstruct the teaching process to monitor, analyses, and diagnose the teaching process, learning situation, and Students’ academic level, which can provide an online question bank and facilitate students' learning (Zou, 2017). Students and teachers can access the AI

(Rain Classroom) teaching platform in colleges, but they also allow the students to learn, preview and review after class without a time limit (Chassignol et al., 2018). The AI (Rain Classroom) can automatically respond to the students' questions, recommend relevant knowledge learning according to the students' mastering level, and achieve personalized learning for each student. One of the advantages is that it is not constraint by time and location (Knox, 2020). The disadvantage of AI (Rain Classroom) is that the user requires a good network. MATLAB has reliable and abundant functions such as calculation, graphics drawing, data processing, image processing, and convenient editing compared to AI (Rain Classroom) and multimedia teaching platforms (Zhou et al., 2020). During the teaching process, MATLAB language is embedded into the application of automatic control theory so that the ACP content becomes intuitive, mobilizing students' enthusiasm and creativity, deepening students' understanding of the theory of automatic control systems, cultivating students' analytical ability and comprehensive ability (Wen et al., 2017). Hence, students do not have to spend too much time on calculations and drawing in this course. Teachers can implement the system simulation software MATLAB to make accurate simulation curves quickly during the lesson. The disadvantage of the MATLAB teaching method is less interaction between teachers and students in the computer classroom. Multimedia courseware can break through the space limitation, save the time of blackboard writing in the teaching process, expand the teaching capacity, enable teachers to transmit more knowledge to expand students' vision, and improve the efficiency of classroom teaching (Shen & Yu, 2021). The biggest difference between multimedia teaching and the teaching platform of AI (Rain Classroom) and MATLAB is that the effect of multimedia teaching depends on the level of teachers to a great extent (Juanjuan et al., 2020). The design of the lesson for the course of the

ACP directly affects the teaching effect because the teaching design is portrayed in the PPT courseware. Teachers in different schools will design PPT courseware according to the selected teaching materials, and some teachers will directly use PPT courseware provided by publishing companies. Therefore, the teaching effect depends on the level of teachers and the understanding of the course of ACP.

In recent years, AI (Rain Classroom), MATLAB, and multimedia teaching platforms have been the primary teaching platforms used to teach automatic control principle. More and more teachers try to use new teaching platforms to improve teaching quality. AI (Rain Classroom), MATLAB and multimedia teaching platforms have their own characteristics in the teaching of ACP. The Rain Classroom platform brings more learning plans to students (Knox, 2020). The Rain Classroom teaching platform based on artificial intelligence technology allows students to study at any place and time. Artificial intelligence technology integrates mobile internet, data mining, cloud computing, big data and other technologies through adaptive learning programs. The Rain Classroom platform can provide many teaching videos for students to learn online, and students can watch them repeatedly, regardless of time and location (Yufei et al., 2020a). Teachers and students can interact and communicate on the Rain Classroom platform. MATLAB teaching platform has good teaching performance and learning aid ability and can provide an intuitive and graphical simulation environment for teaching, so it is very suitable for teaching ACP courses (Xuening, 2013). MATLAB teaching platform can create more practical opportunities for students to quickly understand the abstract concept through perceptual knowledge in the simulation experiment and overcome the shortcomings of traditional teaching. The multimedia teaching method has diversified content presentation, fast and clear screen display, avoiding many blackboards writing by teachers, saving a lot of

classroom teaching time, increases the amount of teaching information, improves classroom efficiency, and helps to improve teaching quality (Mayer, 2008). The interactive mode of multimedia teaching is mainly face-to-face communication between teachers and students during the teaching process. Teachers and students can activate the classroom atmosphere and increase students' interest in learning through communication and interaction. Students can learn in a relaxed and pleasant environment (Wenhui & Ling, 2012).

In the teaching of ACP courses, AI (Rain Classroom), MATLAB and multimedia teaching platforms have similarities and differences. First of all, the similarity is that teachers can teach through the above three platforms and show the students' difficulties in the course. Secondly, in the teaching process of the three teaching platforms, teachers and students can have effective teaching interaction. Finally, teachers can use these three teaching platforms to carry out different forms of teaching activities.

The difference is that AI (Rain Classroom) can reduce students' dependence on teachers, and the AI (Rain Classroom) teaching platform can formulate appropriate learning plans for students. AI (Rain Classroom) can provide rich learning resources for students to preview before class and review after class. The forms of AI (Rain Classroom) in teaching interaction are diverse (Xue & Zhang, 2021). The special feature of the MATLAB teaching platform is that teachers can use MATLAB functions to visualize the course's content, which is easy for students to learn and understand. At the same time, the MATLAB teaching platform provides a good simulation experiment platform for students to learn (Liu & Hu, 2012). The difference between the multimedia teaching platform is that it can give full play to teachers' teaching styles.

At the same time, the multimedia teaching platform presents a variety of course content, which is the most familiar teaching method for students and teachers (Xu, 2017).

The importance of comparing three different teaching platforms to students' conceptual understanding and innovative thinking is mainly reflected in the following five aspects:

1. With the development of artificial intelligence technology, teaching platforms in universities are also diversified. Various online teaching platforms and smart classroom teaching platforms have emerged. The education field is gradually deploying more and more new teaching methods. The research evaluates the impact of different teaching platforms in enhancing students' conceptual understanding and innovative thinking and collects relevant research data. Researchers dig out useful information from these data that are helpful for educational decision-making and the optimization of the teaching process. Moreover, through the analysis of relevant research data, it can improve the teaching platform, curriculum construction and teacher teaching evaluation, and other aspects to play its value.
2. Studying teaching methods on different platforms is an important guarantee for improving teaching quality. Different teachers teach the same teaching content, and the teaching effect will differ. In addition to the lecturer's level and teaching attitude, the key is that the teacher adopts the teaching methods of different teaching platforms (Chenggong et al., 2006). The scientific teaching method is to help students better learn related knowledge and improve the quality of teaching.

3. Studying the teaching methods of different platforms can broaden students' access to education, obtain more abundant and high-quality educational resources, and promote education fairness. It also helps students to choose more suitable learning ways, which is of great practical significance.
4. This research uses the relevant theoretical framework, finds different teaching methods for students' conceptual understanding and innovative thinking, and analyzes which teaching method better meets students' conceptual understanding and innovative thinking. It provides theoretical and practical significance for the reform and development of university teaching (Chen et al., 2021).
5. Using different teaching platforms, teaching methods have their specific suitable environment, so according to the teaching content, classroom teaching should pay attention to the flexible diversity of teaching methods. The relevant research provides a reference for teachers to choose different teaching platforms, optimize teaching efficiency, give full play to the maximum potential of each teaching method, and optimize the integration of various teaching methods to improve teaching efficiency and improve the quality of education and teaching.

This study mainly compares the influence of different teaching platforms on students' conceptual understanding and innovative thinking during ACP course. The primary purpose of this study is to find out how the different teaching platforms affect students' conceptual understanding and innovative thinking ability through a comparative analysis and find out which platform can promote students' conceptual understanding and innovative thinking ability to provide a reference direction for enhancing the teaching reform of ACP course. The finding of this research is expected

could provide a guide for the teachers to know how to use different teaching platforms to improve the teaching effect of the ACP course and provide a reference direction for teachers' teaching.

1.3 Problem Statement

With the blossoming of science technology and more advanced technology used in teaching, teachers and students will face more challenges and opportunities (Price, 2019). Modern education requires students to have better innovative thinking and conceptual understanding ability, so as to faster adapt to school learning and social development. In the teaching process of the new era, schools, teachers and students are faced with many problems to explore and solve. In this section, several questions will be introduced.

1.3.1 Development of AI in the Teaching and Learning Process in Higher Education Institutes

With the rapid development of artificial intelligence technology, increasingly, countries have begun to pay attention to applying artificial intelligence technology in the teaching process (Sugumaran et al., 2021, Zengyuan & Junnan, 2019). Many countries worldwide have introduced relevant policies and issued documents to show support and strive for the development of AI education (Guilherme, 2019). The current application of artificial intelligence in education is an inevitable trend. There are many intelligent auxiliary learning tools, such as taking pictures and searching for problems, arranging courses, evaluating oral skills, scoring, marking papers and preparing homework. (Wang & Tao, 2018). These teaching aids adopt advanced artificial intelligence technology, which provides a lot of convenience for teachers and students in the teaching and learning process. Majority of the use focuses on primary and secondary school. It has always been a question for many researchers to think about

how to integrate artificial intelligence technology into university teaching and student learning (Wang et al., 2018). AI technology helps to improve the ideas and methods of learning. Not only that, it helps students in the comprehension of professional concepts and cultivates the innovative thinking among students.

A few possible reasons exist for the lack of AI technology in higher institutes' teaching and learning processes. From the school's point of view, the price of AI teaching equipment may be high, which brings a great financial burden to the school's operating costs. The rapid development of artificial intelligence (AI) technology has promoted the reconstruction of the human social order. The development and application of artificial intelligence technology have promoted the transformation of college students' employment structure and have had many effects on the cultivation of talents in colleges and universities. (Florea & Radu, 2019). Among these influences, Artificial intelligence puts forward new requirements for higher education personnel training norms. Promote the transformation and upgrading of the university environment, reshape the university's development, and promote the change of the role of teachers. (Zengyuan & Junnan, 2019). As for the teachers, many are still used to the traditional mode of teaching which revolves around teachers delivering the lessons while the students passively receive the knowledge from them. Based on the students' perspective, they still prefer the exam-oriented mode of education. The Students' goal is only to pass the exam, but not to truly understand the knowledge learnt or to have an innovative thinking and the ability to think independently (Shih, 2019). Students mainly still learn by attempting questions and they have lost the ability to reason.

1.3.2 Difficulties in Understanding Concepts for Chinese Students in the ACP Course

The ACP course is quite boring being a fundamental theory lesson as the syllabus emphasizes methodologies and it is all about theories, abstract concepts, huge capacity of mathematics and complicated calculations, causing students to face difficulty to comprehend it. The concepts of ACP course content can be roughly divided into three parts: basic concepts, time-domain analysis, and frequency domain analysis. Students usually have difficulty understanding when they study these parts. The basic concepts contain very abstract content, which is difficult for students to understand. The time-domain analysis concepts and frequency domain analysis concepts have complex mathematical operations, and physical concepts can lead to misunderstandings and difficulties for students to understand. Because of the characteristics of the ACP course, such as a wide range of knowledge and strong specialty, Zeng Zhiqiang adopted the visual teaching method to make full use of modern electronic technology, multimedia technology and simulation technology to help students understand basic concepts (Zeng Zhiqiang, 2022). In view of the teaching process of the electronic information specialty of the Civil Aviation University of China, students reflect the problems of abstract curriculum concepts, theoretical analysis, high mathematical requirements, and disconnection from practice (Kun, 2019). During the lesson, students may find the content being very abstract and difficult to understand. The subject matter requires students to have a good foundation in mathematics and better ability in abstract thinking. In a traditional classroom, students will have a lot of learning concepts left not understood. Students who are not strong-willed give up in the middle of the learning process (Jiao et al., 2018). This results in their weak parts in learning to be accumulated causing a decline in academic performance and then students are satisfied by a mere pass in the exam. As the teaching

and learning of the automatic control principles is mainly delivered via lecturing, this causes students to find it difficult to apply the theoretical knowledge in solving practical problems. Students are forced to accept several formulae and theorems but not to explore it at their free will. This further increases the difficulty of students in conceptual understanding (Min, 2018). When encountering a specific problem, students are aware of the problem per se but fail to ascertain the root cause of it since they do not understand the concepts thoroughly and hence they cannot apply the theoretical knowledge they learnt in solving practical problems (Jiao et al., 2018). Another portion of students also try very hard learning the subject following their teachers' guidance but still they do not understand a few of the concepts. Thus, the new teaching methods and tools need to be introduced in the teaching and learning of the ACP to help the students to understand the concepts (Xiaoxiao et al., 2018).

1.3.3 Problems of Innovative Thinking Cultivation in the ACP Course Learnt by China Students

In today's era whereby technology is advancing, innovative thinking and innovative ability have slowly become the key determining factor in the respect of the nation's competitiveness worldwide and its international status (Yingkai, 2018). Up for now, China's higher education places a lot of emphasis on innovation and "Automatic Control Principles (ACP)" is indeed a good course to guide the students to think innovatively (Rui, 2015). However, for all the while, the teaching of the course exhibits problems such as the course is too theoretical and has lost contact with reality as well as having teaching methods that are not diversified.

These problems cause students to display a lack of interest in the learning process and become inactive learners. Besides, the comprehension of the control theories is only at the mathematical formulae level while some basic concepts which

are abstract are found difficult to be understood by students (Jiliang et al., 2018a). The theoretical content is dull and has loose connection with actual practice. Students exhibit insufficient ability in comprehensive analysis and solving of problems. Moreover, in their learning journey, students appear to be more confused the more they learn. They failed to grasp the main focus of the course as well as the system and continuity of the before and after content. Thus, it is difficult to cultivate the students' innovative thinking and imagination (Xiaohong & Yinan, 2018). Students spend longer time on learning theories while they spend less time on hands-on experiment and simulation control process; this also restricts the cultivation of the desired mindset. Another part of the reason is the evaluation system of the course is a test indicator in static form. The evaluation of the teaching effectiveness and student ability employs a standardized evaluation method. Standard and norm-referenced test papers are used to evaluate teachers and students who are initiative and creative, thus obliterating their creativity (Yongquan & Chen, 2010).

The current situation is such that there is still a lack of innovative thinking cultivation in the ACP course learnt by majority of the China students. The cultivation of innovative thinking in the course of ACP is mainly through observing, questioning, networking, experimenting and other practical aspects, strengthening students' participation in practical activities, linking theory with practice, and helping to cultivate students' innovative thinking ability (Wu & Wu, 2020). In the actual teaching of the ACP course, the students lack the observation of the existing control system and the control process, and the teachers do not pay attention to the cultivation of the students' observing ability (Yinshui & Zhuohua, 2021). Mulgan believes that only by careful observation of things can discover and innovate (Mulgan, 2006).

In terms of the networking, it is reflected that there are not many ways for teachers to provide students with academic exchanges, and there are fewer opportunities to participate in student forums. Kivimäki et al. (2000) believe that students can be inspired to innovate by increasing communication and interaction (Kivimäki et al., 2000). The problem faced in questioning is that the current teaching of the ACP is based on teachers. In the classroom, students have few opportunities to ask questions, and the interaction between teachers and students is not frequent. In the teaching process, the course content is mainly displayed to the students in the form of PPT teaching. In experimental teaching, students lack the opportunity for simulation experimenting. Li Ying's research enables students to fully cultivate innovative thinking in experimental design, operation, observation, and analysis (Li, 2011).

1.3.4 Problems Faced by Teachers of Higher Institutes in China in the Teaching of the ACP Course

For now, in the teaching of the Automatic Control Principles (ACP), teachers face a problem, which is the abstract complicated control process can only be explained to students through building mathematical models and abstract mathematical equations. Students find that the understanding of the subject matter to be rather difficult (Kecai et al., 2019). Under the conventional mode of teaching and learning, when explaining the ACP, teacher mainly draws a lot of diagrams such as time-domain response graphs, frequency-domain response graphs and root locus graphs on blackboards to aid analysis (Nianxue, 2019). There is still a large difference between the actual curves and hand-drawn curves; this creates a significant number of problems to teachers when teaching. Based on diagrams hand-drawn on blackboards, it is not easy for students to observe the impact of the change in parameter towards the stability and dynamic characteristic of the control system. Students cannot understand

the theories thoroughly and expand ideas from it, not to mention the waste of time when teachers are drawing in a traditional classroom and the poor human drawings (Haitao et al., 2015). In the teaching process, teachers can use the combination of theory and practice to teach and provide students with various teaching materials. But most teachers only use blackboard writing and PPT in the teaching process. And in the teaching assessment process, students are also considered to be supplemented by test paper scores and usual scores. This teaching and assessment method makes students less interested in learning and less motivated. At the same time as the course is complicated and the content contains a lot of abstract concepts, the teaching and learning process is very uneasy and the students' learning efficiency is not high. Teachers spend a lot of their time in preparing the subject content. Plus, their teaching methods focus more on the students' result. The students' personality growth and cultivation of the innovative thinking are not given much emphasis by the teachers in the class.

1.3.5 Problems Faced by China Students in the Learning of the ACP Course

The ACP course content is varied. Some teachers teach a lot of theoretical knowledge during the teaching process, which makes it difficult for students to absorb and understand. For example, regarding thermodynamics, teachers explain electronic information technology and let students build models to solve problems through MATLAB. In the actual teaching process, it is difficult for students to learn and understand more knowledge quickly. Many students have misunderstood concepts. In the process of studying ACP courses, students not only need to combine multi-disciplinary knowledge but also need to have a certain ability for independent thinking and innovative thinking (Hongjian, 2016a). However, some teachers only follow the

teaching assessment standards, making it difficult for students in the learning process, resulting in a certain fear of learning.

Generally, students in colleges and universities have a poor foundation in theoretical subjects, especially Mathematics. They do not show much interest in learning the theoretical knowledge of the ACP (Xianlei & Jiuling, 2016). They learn the subject by mainly attending classes and acquiring knowledge from listening to the teacher's lecture (Huzhang, 1984). Due to this sole mode of accepting knowledge, it affects the cultivation of the students' innovative thinking to a great extent. By mainly accepting knowledge delivered by the teachers, the students are lack of dialectical thinking and their personal growth are not exemplified. While learning the ACP course, many students only master a few conversion of equations and drawing of diagrams (Liepin, 2004). However, they neglect the fundamental idea of automatic control and law of physics behind the mathematical equations. Thus, they find it difficult to apply the theoretical knowledge learnt in solving actual engineering problems.

The insufficient use of advanced teaching aids, AI equipment and MATLAB Platform result in students having to spend a lot of time and effort finishing many assignments given by teachers. The students' learning efficiency is hard to be given assurance. Students who accept information easily may find the subject to be relatively easy while others who are poor at accepting information may find the lecture content to be difficult to comprehend and find learning laborious (Pin, 2014). This causes students to be unable to have an innovative thinking.

1.3.6 The Limitation of Research

For the purpose of this study, the research sample is composed of college students majoring in automation at applied universities in a specific province in China. The teaching materials and syllabus of the ACP course they use are mainly designed

for applied college students, so the research results may not be extended to vocational-technical colleges and some top universities.

The students for this research consist of junior students majoring in automation. The main assessment is the conceptual understanding and innovative thinking ability of automation students in ACP, so the survey results may not be generalized to other majors or students who have not studied the ACP course.

This study uses Control System Concept Inventory (CSCI) to assess students' conceptual understanding of ACP course. CSCI is a test inventory for conceptualizing ACP courses. It is mainly divided into basic concepts, Time-domain analysis concepts and Frequency-domain analysis concepts. The CSCI test inventory is primarily used in control theory and ACP courses.

Semi-structured interviews and a small sample for qualitative research also are limitations of the study. Interview data always creates a uniquely challenging problem for data analysis and the generalizability of results. This is because interviewed students may rely on their everyday and colloquial language to explain scientific concepts and give their opinions, rather than researchers seeking scientific explanations and arguments. Although semi-structured and mock interviews are designed to probe students' current concepts and clarify any ambiguities in students' language, researchers still may misinterpret students' responses. Since the interpretation of linguistic meaning is always a difficult task, independent checks of validity by researchers would help reduce the impact of this problem.

The document analysis of this research is an analysis of the topics of conceptual understanding and innovative thinking in the ACP course syllabus. Therefore, the findings may need to be reanalysed as they may be generalized to other courses' syllabus. The syllabus of different majors has different requirements for students'

ability to understand concepts, and the requirements for students of different majors to understand the same knowledge are also different. At the same time, the syllabus of different courses has different requirements for cultivating students' innovative thinking abilities.

1.4 Research Objectives

The current research includes the following objectives:

1. To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' conceptual understanding in the ACP course.
    a) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' conceptual understanding of the General Basic Concept of ACP in the ACP course.
    b) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' conceptual understanding of the Concept of Time Domain Analysis in the ACP course.
    c) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' conceptual understanding of the Concept of Frequency Domain Analysis in the ACP course.
2. To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' innovative thinking in the ACP course.
    a) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' innovative thinking on the observing aspect in the ACP course.

b) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' innovative thinking on the questioning aspect in the ACP course.

c) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' innovative thinking on the networking aspect in the ACP course.

d) To compare the effects of AI (Rain Classroom), MATLAB, and Multimedia teaching platforms in enhancing students' innovative thinking on the experimenting aspect in the ACP course.

3. To investigate students' perceptions of using AI (Rain Classroom), MATLAB, and multimedia teaching platforms in enhancing students' conceptual understanding and innovative thinking in the ACP course.
4. To investigate teachers' perceptions of using AI (Rain Classroom), MATLAB, and multimedia teaching platforms in enhancing students' conceptual understanding and innovative thinking in the ACP course.

1.5 Research Questions

Based on its objectives, the study tries to elicit and deal with the following questions:

RQ1: Are there any significant differences in enhancing students' conceptual understanding in the ACP course when using AI (Rain Classroom), MATLAB and Multimedia teaching platforms?

RQ1a: Are there any significant differences in enhancing students' conceptual understanding of general basic concept of ACP in the ACP course when