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THE EFFECT OF DORMITORY LABORATORY TOOLS (DLT) ON THE ENGINEERING QUALITY OF CHINESE ENGINEERING STUDENTS UNDER INTELLIGENT LEARNING ENVIRONMENT



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THESIS PRESENTED TO QUALIFY FOR A DOCTOR OF PHILOSOPHY

FACULTY OF COMPUTING AND META-TECHNOLOGY
UNIVERSITI PENDIDIKAN SULTAN IDRIS
2024



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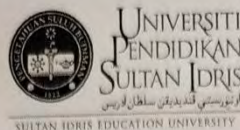
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APPRECIATION

Three years of intense and fulfilling doctoral study career is coming to an end. As I complete my graduation thesis, I want to take this opportunity to express my gratitude to all those who have helped and encouraged me over the past three years and to express my most sincere thanks.

Firstly, I would like to express my appreciation to my supervisor Dr Suhazlan bin Suhaimi for the assistance during this entire process. At the beginning of my doctoral studies, my supervisor helped me get through the confusing phase and enter research fields of study as quickly as possible. Dr. Suhazlan's rigorous academic attitude, solid and profound academic foundation, and scientific spirit of seeking truth from facts have always influenced me. It was a privilege to be guided by him during my doctoral studies.

Secondly I want to say thank you to my co-supervisor Nazre bin Abdul Rashid and two examiners Prof. Madya Ts. Dr. Abu Bakar bin Ibrahim and Dr. Mad Helmi bin Ab. Majid. Thanks for the academic help they provided me in my research.

I also want to express my gratitude to the Faculty of Computing and Meta-Technology for providing me with such a wonderful experience further to my PHD'S degree. Thank you to everyone who contributed to the completion of this research study, both directly and indirectly. I will never regret one moment of my encounter with the Faculty of Computing and Meta-Technology.

Finally, I thank my family for their unwavering love and support throughout every phase of my life.

ABSTRACT

The Fourth Industrial Revolution is reshaping higher engineering education in China, necessitating the adoption of online teaching methods. Massive Open Online Courses (MOOCs) have emerged as a prominent educational tool, offering accessibility, scalability, and diverse resources. However, existing MOOCs often lack practical platforms and projects crucial for engineering students' skill development. This study examines the effect of the integration of DLT with MOOCs in an Intelligent Learning Environment (ILE) on the academic performance and qualitative achievement of engineering students. A combined method approach with a pre and post quasi-experimental research design was employed, utilizing an electronic system design test verified by three experts in education and engineering. Data collection is done by using academic achievement tests, questionnaires and focus group interviews. Data analysis was performed using a T-test involving 60 study participants showing that there was a significant difference between the control group and the experimental group for academic achievement and engineering quality (pretest $t=-0.464$, $p=0.644$; post test $t=8.286$, $p=0.000<0.001$). These findings show the scores of the experimental group were significantly higher than those of the control group which indicate using DLT combines with ILE can effect engineering students' academic performance and engineering quality. Focus group interviews with 10 students found respondents agreed that DLT is beneficial to assist students in learning Electronic System Design, emphasizing the need for its development and integration. The study shows that small, integrated and mobile DLT tools, supported by an intelligent learning environment, positively influence engineering education. These findings have broader implications for students and industry stakeholders in China and globally. Future research should explore innovative strategies for optimizing DLT usage in conjunction with MOOCs and exploring its broader implications for higher engineering education and related fields.



KESAN ALAT MAKMAL ASRAMA (DLT) TERHADAP KUALITI KEJURUTERAAN BAGI PELAJAR KEJURUTERAAN CHINA DALAM PERSEKITARAN PEMBELAJARAN PINTAR

ABSTRAK

Revolusi Perindustrian Keempat sedang mengubah lanskap pendidikan tinggi bidang pengajian kejuruteraan di China yang memerlukan sokongan penggunaan kaedah pengajaran secara dalam talian. Kursus Terbuka Raya Dalam Talian (MOOCs) telah muncul sebagai alat pendidikan yang menonjol, menawarkan kebolehcapaian, kebolehskalaan dan sumber yang pelbagai. Walau bagaimanapun, MOOCs sedia ada mempunyai kekurangan platform praktikal dan projek yang penting untuk pembangunan kemahiran pelajar kejuruteraan. Kajian ini bertujuan untuk meneliti kesan integrasi DLT dengan MOOCs dalam Persekitaran Pembelajaran Pintar (ILE) terhadap prestasi akademik dan pencapaian kualitatif pelajar kejuruteraan. Pendekatan kaedah gabungan dengan reka bentuk penyelidikan kuasi-eksperimen pra dan pasca digunakan dengan melaksanakan ujian reka bentuk sistem elektronik yang telah disahkan oleh tiga pakar dalam bidang pendidikan dan kejuruteraan. Pengumpulan data dilakukan menggunakan ujian pencapaian akademik, soal selidik dan temubual kumpulan fokus. Analisis data dijalankan menggunakan ujian T yang melibatkan 60 peserta kajian menunjukkan terdapat perbezaan yang signifikan antara kumpulan kawalan dan kumpulan eksperimen untuk pencapaian akademik dan kualiti kejuruteraan (ujian pra $t = -0.464$, $p = 0.644$; ujian pasca $t = 8.286$, $p = 0.000 < 0.001$). Penemuan ini menunjukkan skor kumpulan eksperimen adalah lebih jauh lebih tinggi daripada kumpulan kawalan yang menunjukkan penggunaan DLT yang digabungkan dengan ILE boleh mempengaruhi prestasi akademik dan kualiti kejuruteraan pelajar. Temubual kumpulan fokus dengan 10 pelajar mendapati responden bersetuju bahawa DLT bermanfaat untuk membantu pelajar dalam menbelajari Reka Bentuk Sistem Elektronik, juga menekankan keperluan untuk pembangunan dan pengintegrasian. Kajian ini menunjukkan bahawa alat DLT yang kecil, bersepadu dan mudah alih dan disokong oleh persekitaran pembelajaran pintar telah memberi pengaruh positif kepada pendidikan kejuruteraan. Penemuan ini mempunyai implikasi yang lebih luas untuk pelajar dan pihak berkepentingan untuk mengoptimumkan penggunaan DLT bersama MOOCs dan meneroka implikasinya yang lebih luas untuk pendidikan tinggi kejuruteraan dan bidang berkaitan.



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LIST OF ABBREVIATIONS

ADDIE	Analysis Design Development Implementation Evaluation
AR	Augmented Reality
ARCS	Attention Relevance Confidence Satisfaction
DLT	Dormitory Laboratory Tools
DW	Durbin Watson
EDA	Electronic Design Automation
ILE	Intelligent Learning Environment
K-12	Kindergarten Through Twelfth Grade
MOOCs	Massive Open Online Courses
PCB	Printed Circuit Board
PLT	Pocket Laboratory Tools
RC	Resistance Capacitance
SPSS	Statistical Packages for the Social Science
TEL	Technology Enhanced Learning
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

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CHAPTER 1

INTRODUCTION



1.1 Introduction

Higher engineering education plays a crucial role in shaping the future of the engineering profession and promoting technological progress (Maria et al., 2018). The two important factors in higher engineering education are engineering students and engineering quality. With the accelerated development of education in China, it is urgent to cultivate and shape outstanding engineering students and strive to improve the engineering quality of all engineering students (Wang, 2023). With the global impact of COVID-19, online teaching has become a new teaching method in higher engineering education. In order to ensure that engineering students can conduct





practical courses normally, this study designed DLT for engineering students to learn and use in order to improve their engineering quality. DLT are micro tools that miniaturize the functions of traditional experimental equipment onto a small board. They are small in size, easy to carry and operate, and students can conduct experiments anytime and anywhere. These DLT can replace traditional laboratories and enable engineering students to engage in online practical courses, participate in practical activities, and improve practical skills and other engineering qualities. This chapter mainly discusses the research background, states the research problem, clarifies the research objectives, proposes research questions and hypotheses, determines the research framework, lists some operational definitions and limitations of the study, and finally concludes with the research significance.



1.2 Background of Study

World higher engineering education (or engineer education) originated in France during the Industrial Revolution. France's higher engineering education was defined from the beginning as an elite education that determines national competitiveness, playing a crucial role in the economic development, technological progress, and modernization process of various countries (Li & Liu , 2010). Higher engineering education plays a crucial role in the entire innovative education system in China. China's higher engineering education should conduct various beneficial explorations





around promoting educational innovation, and strive to cultivate high-level, high-quality, diverse, creative engineering technology talents with international perspectives and adapting to the requirements of the times. Therefore, China's higher engineering education must accelerate reform, adjust the disciplinary and professional structure, hierarchical structure, and talent training mode of engineering education.

Qu Zhenyuan (2017) mentioned that the engineering quality of engineering students is the core and key point to comprehensively improve the training quality of engineering talents. In recent years, returning to engineering practice is the main direction of the development of higher engineering education. What kind of engineering and technical talents to cultivate and how to cultivate engineering and technical talents are one of the most urgent tasks of higher engineering education in China. However, with the tide of smart earth sweeping the world and the rapid development of smart education, if we still use yesterday's education method to train future engineering students, we will destroy tomorrow's education. Therefore, conforming to the trend of educational informatization and educational intelligence, changing the educational concept of engineering students, innovating training methods, and paying full attention to the shaping and training of engineering students' quality is not only the inevitable trend of engineering education in China, but also the inevitable requirement of educational reform.





In February 2017, China put forward the "new engineering" strategy, and the transformation of training concept is one of the key tasks of the construction of new engineering. How to cultivate diversified and innovative future engineering talents to meet future challenges has become a topic of common concern among enterprises, universities, teachers and students (Li et al., 2018). Workshop workers engaged in mechanical work have been gradually eliminated by the society. What emerging industries and the new economy need are high-quality "new engineering" talents with strong engineering skills, strong comprehensive skills, complete professional knowledge and international competitiveness. Therefore, in the "new engineering" environment, the change of engineering education and training concept promotes the continuous adjustment and innovation of the training mode of engineering students.



At present, the training methods of engineers in colleges and universities urgently need to be changed mainly because other teaching methods are widely spread. The traditional teaching method is to instruct the teacher to explain systematically and meticulously to enable students to master a large amount of knowledge, and the form is relatively simple. Generally, the teacher stands on the podium to speak, and the students passively accept it below. In this teaching method, the teacher has a relatively large degree of freedom, and what the students receive is a passive learning experience. Regarding this point, the traditional teaching method is often called cramming teaching. (Li,2022). This results in limited student engagement and reduced motivation, disinterest, and lack of individual commitment.





Traditional teaching methods pay too much attention to theoretical concepts and neglect the practical application of visual engineering principles (Zhang& Qi,2021). This leads to a deviation between classroom learning and practical engineering practice, making it difficult for students to connect theoretical knowledge with practical technology, which will directly affect the improvement of engineering students' engineering quality.

Traditional teaching methods often prioritize examination of individual work and evaluation, which may limit opportunities for association work-learning and development of communication and teamwork skills (Zhang, 2023). Engineering professionals need strong collaboration skills to work effectively in multidisciplinary teams.

Traditional teaching methods usually emphasize students' rote memorization instead of encouraging critical thinking, analytical reasoning, and problem-solving skills (Wang, 2021). This fails to adequately develop the problem-solving skills that are critical to engineering talent.

Most engineering students need to study practical courses. The traditional teaching method requires that all engineering students who need to study practical courses must have physical attendance. However, due to the impact of the COVID-19 and the continuous improvement and innovation of teaching methods. Many higher





engineering universities in China have started to choose online practical teaching. However, traditional teaching methods can no longer meet the needs, and colleges and universities must explore new teaching methods. In order to solve these problems, this study designed DLT suitable for engineering students in our school, so that students can conduct online experiments anytime and anywhere.

As a new teaching mode, DLT are mainly characterized in that students can carry "pocket" experimental equipment and perform experimental operations at their own choice of occasion and time (Ou, 2020). Compared with the traditional laboratory teaching method that requires a fixed time and place, the teaching mode of DLT can enable students to have more time and opportunities for independent operation and learning, and quickly improve their hands-on ability and practical ability. "Pocket" equipment and teaching content are easy to update, so that the learning content meets social needs, thereby improving students' professional and technical capabilities and expanding students' employment direction.

The wide application of smart classrooms and MOOCs in Chinese universities also creates the possibility of providing ILE. As an important place to support learning, intelligent classroom and MOOCs will have an impact and freshness on "learning and teaching" from all aspects of resources and methods. With the help of information technology, it is conducive to form students' personalized learning plan,





capture students' learning information in real time, form scientific analysis, and then improve teaching.

The DLT was used to carry out the practice of shaping and improving the engineering quality of engineering students in the smart classroom, mainly focusing on the engineering skills, comprehensive skills, engineering ethics, professional knowledge and other issues of engineering students(Fan,2022). The research attempts to focus on the DLT for engineering students, solve the problems related to the improvement of engineering quality of engineering students, and promote the development of higher engineering education to a higher level. Thinking and research on the cultivation of engineering quality of engineering students in ILE, and precipitation, reflection and summary from teaching practice.

Integrating ILE into DLT, students can engage in hands-on activities, conduct virtual experiments, and solve real-world engineering problems. Practical application of this knowledge enhances their understanding, critical thinking, problem solving and hands-on skills; Students also participate in collaborative projects, participate in online discussions and work together on engineering tasks. This collaborative learning approach promotes teamwork, communication skills. Give students anytime, anywhere access to educational materials and resources. This flexibility allows students to study and engage in learning activities on their own schedule, promoting self-paced and independent learning(Liu et al., 2022).





While both areas of ILE and DLT have received separate attention in the literature, the intersections between them have not been extensively explored. The interdisciplinary integration and cooperation of DLT and ILE is an emerging trend in the field of higher engineering education, and this direction is a gap in the existing literature. This study integrates the two, which provides a basis for current research, and also contributes and proposes new ideas for the future impact of DLT on other aspects of engineering students(Madritsch,2023).

Therefore, according to the above research situation, this section establishes the background of the research. This study designed DLT suitable for engineering students to learn and use according to the needs. Combined with ILE, focusing on the engineering quality of engineering students, solving the problems affecting the improvement of engineering students' engineering quality, and promoting higher engineering education to a higher level development. Thinking and research on the improvement of engineering students' engineering quality in ILE has pointed out a clearer research direction for future research, and provided a reference for China's practical course teaching, higher engineering education and even other teaching fields in the post-epidemic era.





1.3 Problem Statement

The development of information technology and the continuous reform of higher engineering education in China, the requirements of the country and enterprises for the engineering quality of engineering talents are constantly increasing. Engineering quality is a collection of multiple aspects, including personal knowledge, abilities, and cultivation, especially practical ability. To build an innovative country and a strong talent country, it is necessary to cultivate a large number of high-quality engineering and technical talents (Luo, 2015). In order to cultivate and improve the engineering quality of engineering students, online education such as ILE has gradually become popular, and MOOCs(Massive Open Online Courses), as a form of online courses, continues to attract more and more engineering students.

MOOCs are of great significance for higher engineering education. MOOCs integrate various social networking tools and forms of digital resources to form diverse learning tools and rich course resources; Breaking through the limitations of traditional courses in terms of time and space, relying on the Internet, learners from all over the world can learn famous university courses at home and abroad; At the same time, breaking through the limitations of traditional course numbers can meet the needs of large-scale course learners; Unlike traditional classroom teaching methods, MOOCs emphasize students' initiative and autonomy. Students need to adjust their learning progress and develop learning plans. This learning method can





cultivate students' self-learning ability, improve their learning efficiency and confidence. Moreover, the MOOCs platform has more high-quality practical functions such as teacher-student interaction (barrage, etc.), real-time courseware push, real-time test feedback, data collection, timely generation of classroom reports, real-time tracking, and evaluation of learning progress. Its rich resources provide support for intelligent teaching (Li et al., 2020).

However, MOOCs can only provide theoretical learning, and the existing MOOCs theoretical courses lack a real practical platform and projects, which cannot effectively improve the practical ability of engineering students. Lin said there was a widespread problem in China's higher engineering education that emphasizes theory over practice, and books over skills. These phenomena result in engineering students' engineering qualities not being in line with the needs of modern science and technology, especially in the course of electronic system design (Lin, 2018).

In response to this problem, this study designed DLT to compensate for this deficiency. DLT breaks through the limitations of traditional laboratories due to space limitations and open hours, allowing students to use their spare time to engage in online practice anytime and anywhere outside the laboratory, such as dormitories. The dormitory laboratory tool provides a dedicated space for engineering students to participate in experimental learning experiences, providing a platform for students to directly connect theoretical concepts learned in the classroom with practical





applications. (Hua, 2019). Combining MOOCs with DLT the theoretical knowledge of MOOCs is truly loaded onto the entity platform through DLT, allowing students to systematically learn and form a complete learning system of "theory+practice".

1.4 Purpose of the Study

With the rapid development of new industry and new economy, cultivating new engineering talents has become an inevitable choice for the country. However, the engineering students who grew up under the traditional education pay more attention to theory than practice. Although their theoretical achievements are excellent, they still have some shortcomings, such as insufficient engineering skills and comprehensive skills, weak engineering ethics and engineering consciousness(Wang et.al.,2018). Now society requires engineering talents to have broad theoretical knowledge and solid practical ability. However, there are few talents with comprehensive engineering quality. Therefore, cultivating and improving the engineering quality of engineering students is not only an important measure of higher education reform, but also the main focus of this study.

The purpose of the study is to design and develop the DLT which combined with ILE.By loading the theoretical learning of ILE onto a physical platform through DLT, allowing Chinese engineering students that take Electronic System Design course to



systematically learn and form a comprehensive learning system of "theory+practice", thereby improving their hands-on practical skills, problem-solving and analytical abilities, as well as professional knowledge and other engineering qualities. This study relying on the support of ILE, and based on ARCS theory and ADDIE theory to establish a theoretical hypothesis on the impact of DLT on engineering quality. Learning and using DLT are carried out in detail, and the specific impact of DLT on engineering students' engineering quality is empirically analysed. An applied strategy for effectively intervening in engineering literacy using DLT is proposed. This study provides constructive suggestions for the reform of higher engineering education and how to improve the engineering quality of engineering students, and points out a clearer research direction for future research on the engineering quality of engineering students. Also provides reference for practical course teaching in higher engineering education, K-12 education, and even other fields in China.

1.5 Research Objective

The specific objectives of this study are as follows:

- (i) To identify the needs of the DLT.

(ii) To design and develop the DLT.

(iii) To design and develop MOOCs.

(iv) To study the need of DLT combine with MOOCs in ILE.

(v) To evaluate the influence of DLT on the engineering quality of Chinese engineering students in ILE.

(vi) To evaluate the influence of DLT on Electronic System Design performance of engineering students.

1.6 Research Question

Q1: Does it need to design the DLT ?

Q2: How to design and develop the DLT?

Q3:How to design and develop MOOCs?

Q4:Does it necessary to study the need of DLT combine with MOOCs in ILE?



Q5:Do DLT affect engineering quality of Chinese engineering students in ILE?

Q6:Do DLT affect students' Electronic System Design performance?

1.7 Research Hypothesis

Based on the research questions, some of the hypotheses have been developed. The hypotheses are as follows:



H1: It need to design the DLT.

H2: It is necessary to study the need of DLT combine with MOOCs in ILE.

H3: DLT would affect engineering quality of Chinese engineering students in ILE.

H4: DLT would affect students' Electronic System Design performance.



1.8 Research Conceptual Framework

According to (Thomas, 2020), engineering quality provides a good atmosphere for encouraging the employment attitude of engineering students; But what are the factors that promote their engineering quality? Few studies have explained the factors affecting the engineering quality level of engineering students. This study attempts to fill this gap in the existing literature.

The study is to determine the impact of DLT on the engineering quality of Chinese engineering students in ILE. When conducting research, we must conceptualize the concepts or factors that need to be studied in order to highlight the structure and the relationship between them. To help this conceptualization, charts are used to describe related concepts and their predictive relationships, as synthesized from the process of literature review. With such a conceptual framework, researchers can confidently and accurately put forward appropriate research questions and research hypotheses to clarify her or his research. In short, such a conceptual framework is the basis for predicting subsequent research activities.

More specifically, the conceptual framework of how researchers think about a particular problem, or how they represent the complexity of a phenomenon, can best be captured through correlative research. These frameworks will emphasize appropriate variables and outcomes and their interrelationships (Bordage, 2009). In



this respect frameworks help to clarify, explain and justify methodological decisions (Ravitch & Riggan, 2012). Therefore, the decision to adopt a particular research method depends on having an appropriate conceptual framework, without which researchers may make methodological errors in their research.

In the study of the impact of DLT on the engineering quality of Chinese engineering students in the ILE, three factors are considered to be important. These factors are considered as correlated variables by which they are divided into one independent variable and one dependent variable. The independent variable is the DLT, which includes four items, namely the design of DLT, supporting effect of ILE on DLT, course design of DLT (Content, Structure, Evaluate), implementation of DLT. The dependent variable (response variable) is the engineering quality of engineering students, which includes five items, namely theoretical knowledge, comprehensive quality, engineering skills, engineering ethics, and engineering awareness. The conceptual framework of this study is based on relevant theories and models, and Figure 1.1 shows the conceptual framework of the study, highlighting relevant concepts or factors and their assumed relationships. As shown below:



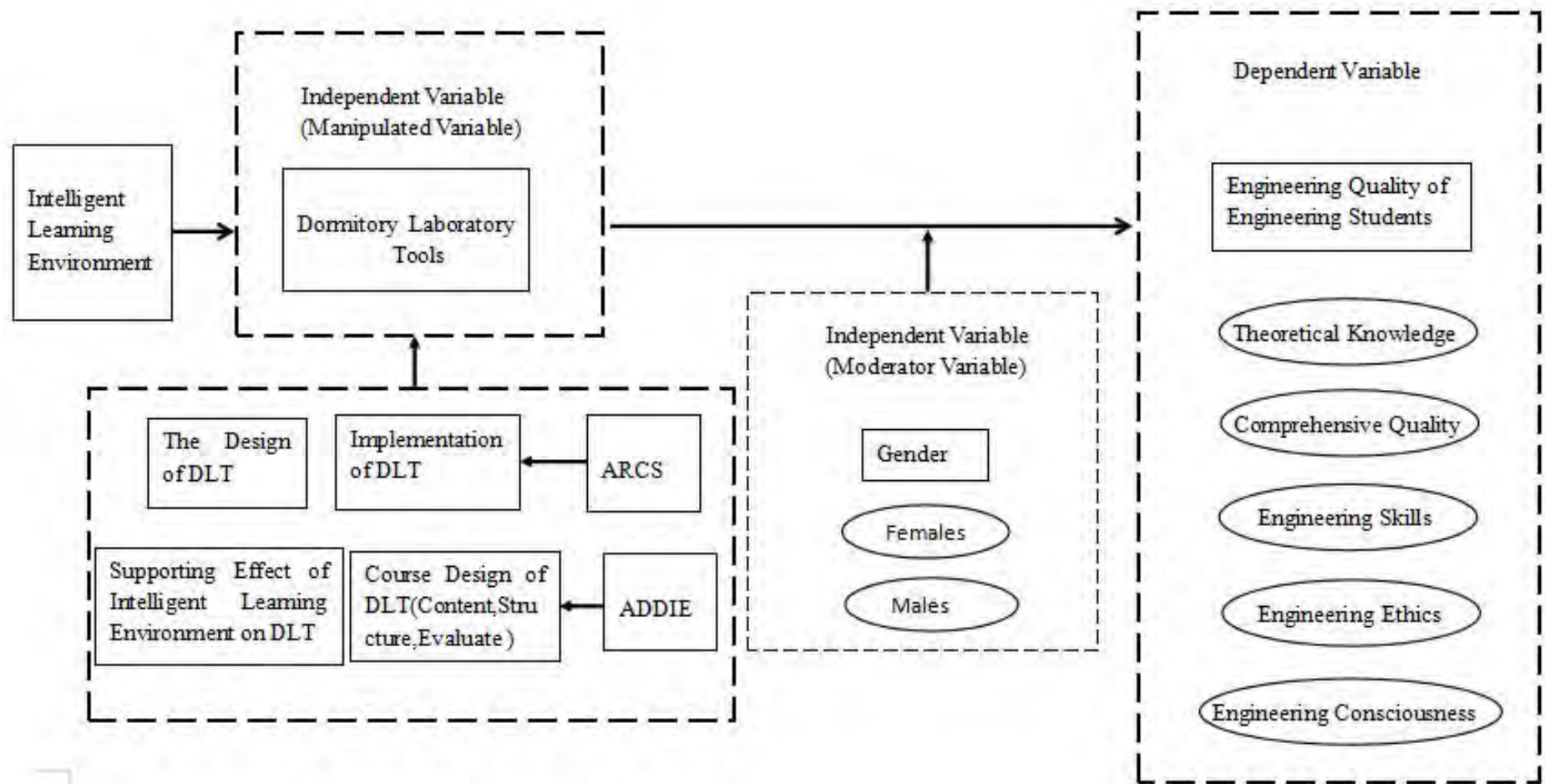


Figure 1.1. The Conceptual Framework of the Study

1.9 Operational Definition

Various terms are used in this study. In order to provide a clearer understanding, the following definitions are given:

1.9.1 Intelligent Learning Environment

Intelligent learning environment refers to a learning place or activity space that can perceive learning situations, identify learners' characteristics, provide appropriate learning resources and convenient interactive tools, automatically record learning processes and evaluate learning results, so as to promote learners' effective learning. Intelligent learning environment can realize the integration of physical environment and virtual environment, and can better provide learning support and services adapted to learners' personality characteristics (Myung & Yoo , 2012).

Some authors have shown that ILE do not present a clear and unified definition (Chen & Xu, 2021). Since many of those are usually based on generic/general principles, such as the five pointed out by the Korean Ministry of Education, Science and Technology: self-directed, motivated, adaptive, resource-enriched and technology-integrated (Huh & Lee,2019). The ILE was first proposed by chin, who is a Malaysian scholar. He believes that ILE is a learner centered environment , based on the application of information and communication technology and has the following characteristics.It can adapt to learners' different learning styles and learning abilities;



It can provide support for learners' lifelong learning; Provide support for learners' development (Chin, 1997).

Wang Fengqi et al. (2013) believe that the constituent elements of ILE include personal learning space, which is a personal learning portal with obvious personality characteristics. Learners selectively aggregate scattered and useful resources, information, tools and services with RS tools, just like personal online learning desktop, to provide learners with "one-stop" services; Social learning platform is a personal learning space that can reflect their own learning themes in the process of finding topics of interest through the use of social network services (SNS); Curriculum management system refers to an information network system with a series of functions, such as making, organizing, tracking, evaluating, pushing, presenting, managing learning contents and activities, and promoting the interaction between learners. The learning resource center is composed of MySQL database and expert system (ITS). Auxiliary learning tools are a series of media and means to help learners learn and communicate, so that learners can enhance their thinking, broaden their horizons and expand their ability. Including cognitive tools and communication tools.

Xie youru et al. (2018) believe that the constituent elements of ILE include: learning resources, with more emphasis on the storage and sharing of generative resources. Intelligent tools, focusing on promoting the generation, capturing and recording of generative information. The construction of learning community emphasizes the interaction, exploration, cooperation and communication between





students, meets the interaction and learning needs of students inside and outside class, and creates more generation opportunities and condition. Teaching community, which emphasizes the unity of joint learning, teaching reflection and professional development among teachers; Teachers and learners interact with the other four elements through generative teaching and learning to jointly promote the occurrence of generative teaching. Learning resources and intelligent tools provide support for the learning community and teaching community. The learning community and the teacher community promote each other, realize the growth of teaching and learning, and promote the enrichment of learning resources and intelligent tools.



In this study ILE refers to MOOCs. MOOCs can provide students with suitable learning resources. For example, Chinese students can register their MOOCs account for independent learning, and there are many learning resources available for learners to learn. MOOCs can provide convenient interactive tools, such as on the MOOCs platform, teachers can initiate signatures, clicks, discussions, exercises, questionnaires, announcements, etc. to interact with students, which provides convenience for teaching. MOOCs can also automatically record students' learning process, such as the teacher posting a video for students to watch on their own. Teachers can check whether students have completed tasks or how many videos they have watched from MOOCs. MOOCs can also automatically evaluate, for example teacher insert a small



test for students and the computer automatically evaluates whether the students' answers are correct.

1.9.2 Engineering Students

Engineering students refer to students majoring in engineering in colleges and universities. They are the reserve force of engineers and have a direct and realistic impact on human development (Unistats, 2018). Taking engineering students as the research object, this study defines engineering students as engineering students in colleges and universities.

1.9.3 Quality

The concept of quality in the Great Dictionary of psychology is defined as: "quality generally refers to a certain inherent quality of an organism. Some anatomical and psychological characteristics "(Zhu, 1989). The definition of quality in Cihai is "people's innate anatomical psychological characteristics" and "quality also gradually develops and matures in social practice" (Cihai, 1980). Both of them reveal the close



relationship between quality and human innate physiology. Marx believes that quality is formed by "acquired" labor and learning accumulation on the basis of congenital physiological conditions. Aurelio Percy mentioned in his book Human Quality: "The improvement of human quality needs to mobilize the world's inhibition, ability and measures in the next few decades" (Percy, 1988).

This study interprets the connotation of quality from a comprehensive point of view, and interprets the concept of quality from the perspective of education. Generally speaking, quality refers to the sum of potential and relatively stable knowledge, ability and character qualities formed and developed by individuals on the basis of congenital physiological conditions and the joint action of acquired environment, school education and other factors.

1.9.4 Engineering Quality

In modern society, the scope of engineering practice activities has gone beyond the traditional engineering field and scope, towards high-precision. The connotation of engineering quality of engineering and technical talents is also changing and developing dynamically. Most scholars have different opinions on the understanding and interpretation of the constituent elements of engineering quality. Some scholars





believe that the constituent elements mainly include: engineering consciousness, basic engineering knowledge, basic engineering skills, engineering ability and quality; Others believe that engineering quality includes engineering thinking, engineering theoretical knowledge and engineering ability (Huang, 2012). From the statements of many scholars, it can be concluded that engineering quality is composed and driven by a variety of elements and characteristics. It is a collection of a variety of internal qualities shown in engineering practice. College Students' engineering quality refers to a practical, innovative, internal and relatively stable subject characteristic and quality gradually formed and developed by college students on the basis of innate participation in learning, engineering practice and other educational activities (Yuan, 1998). This study mainly defines the concept of engineering quality from the perspective of pedagogy. Therefore, according to the above definition of the concept of engineering quality, the constituent quality can be defined as the relatively stable knowledge, ability and character quality that individuals have and show in the process of innovation practice under the joint action of congenital physiological basis and acquired environment, education and other influencing factors.

This study mainly defines the concept of engineering quality from the perspective of pedagogy. Therefore, according to the above definition of the concept of engineering quality, the constituent quality can be defined as the relatively stable knowledge, ability and character quality that individuals have and show in the process





of innovation practice under the joint action of congenital physiological basis and acquired environment, education and other influencing factors.

Engineering quality refers to a practical, innovative, internal and relatively stable subject characteristic and quality gradually formed and developed by college students on the basis of innate learning, engineering practice and other educational activities. Therefore, according to the connotation and constituent elements of engineering quality, under the guidance of the concept of large-scale engineering education and the theory of quality model, and under the background of engineering education returning to engineering practice, the author puts forward the constituent elements of engineering elements of college engineering students, namely: large professional knowledge, engineering skills, comprehensive quality, engineering consciousness, and engineering ethics. These dimensions of quality and ability division and their own meaning are not absolutely separated, but relative. They are a whole and have mutually integrated parts (Chen & Shao, 2018).

a. Large professional knowledge. Large professional knowledge is to divide related or similar specialties into one category, so as to expand and extend the scope and field of this specialty, reflecting the thought of big engineering education. Large engineering talents need to have a "large" professional background in order to meet the comprehensive requirements of the engineering field itself. Cultivating





engineering talents by large professional categories is the systematic and comprehensive essential appeal of the concept of large engineering. The training mode of senior engineering talents based on large majors is in line with the direction of world engineering education reform. Large professional knowledge aims to cultivate the big professional quality of talents, which also reflects the requirements of big engineering education thought on the professional quality of engineering talents. "Made in China 2025" points out that in order to realize the leapfrog development of manufacturing industry, it is necessary to realize technological innovation, and engineering talents with interdisciplinary knowledge base are the key to achieve this goal. Only in this way can the grand goal of "intelligent manufacturing, green manufacturing and personalized manufacturing" be realized. With the accelerated development of information age, the era of Internet plus has accelerated the speed of knowledge updating, requiring engineering and technical personnel to actively learn new knowledge fields, expand new learning space, renew original knowledge structure and enrich their knowledge system. In order to realize the dynamic development of their original knowledge structure, engineering and technical talents must have interdisciplinary knowledge such as natural science, engineering technology and Humanities and Social Sciences, so as to achieve considerable development under the new situation of high integration of informatization and industrialization(Chen,2019).





b.Engineering Skills.It refers to mastering the technology and knowledge required in the engineering field and being able to use the learned knowledge to complete a project ability to do specific work.Modern engineers should not only have basic abilities such as observation, memory and imagination, as well as general skills such as foreign language and computer operation, but also have engineering practice oriented ability and innovation ability. The multi-level and multi type engineering talents trained by engineering education need to meet the special requirements of the engineering environment of large engineering, have the practical comprehensive ability to solve complex engineering problems, flexibly use the learned knowledge and skills, and creatively analyse and solve problems. The future engineers who should be trained by higher engineering education should have three engineering skills: engineering development and design ability, engineering operation skills and engineering application. In the future, engineers and technicians often work in complex engineering situations and will encounter many engineering problems(Jiao,2020).

Therefore, the cultivation of engineering problem analysis ability becomes more and more important. The proposal of engineering problems is the premise and basis for discovering engineering technology innovation points. Through the observation of many engineering technology information in the engineering scenario, doubts and innovation points are generated. The whole core of the project is design, and the





quality of the design team affects the quality of the whole project. Engineering design is the rehearsal of the construction and operation process of the project, which is based on the key point between the overall planning and specific implementation of the project. Engineering operation skill refers to the perfect action mode obtained by manipulating a certain device in engineering activities. The operation skills to be mastered by engineering graduates mainly include: the ability to use technology, skills and modern engineering tools in engineering practice; Ability to skillfully operate experiment or process flow; Skills used in workshops and laboratories. Mastering the operation of equipment and process flow is a necessary skill for future engineering graduates in the face of complex engineering environment. Engineering application ability mainly includes: the ability to use the professional knowledge learned in design. Overall grasp and application ability of relevant knowledge of products produced by the project. Good pressure resistance and working ability to deal with crisis events. Carry out actual project work by using relevant engineering principles; Ability to strictly supervise the product quality of engineering projects; We should have a comprehensive understanding of the new technologies or methods adopted and correctly distinguish their advantages and disadvantages. These three indicators constitute three key dimensions of engineering skills (Jesiek, 2020).

c. Comprehensive Quality. Comprehensive ability is the basic quality of large engineering talents, including: basic quality, ability to analyse and solve problems,





ability of lifelong learning, ability of crisis handling and international exchange and cooperation, and ability of management, communication and cooperation. Among them, engineering practice ability is the promotion point of comprehensive ability, multi-disciplinary background and various abilities are effective supplements to professional ethics and sense of social responsibility. For example, in terms of communication, cooperation and communication skills: college engineering students should deal with all kinds of people and communicate effectively with their teachers and students in the process of learning and living in school. In the classroom, we should express our views and opinions in fluent and accurate language, and quickly communicate with team members and teachers about their doubts and difficulties, so as to achieve the purpose of quickly solving doubts. All these phenomena require college engineering students to have good communication and cooperation skills(Hua et al.,2023).

Learning is a continuous process, and the project of knowledge accumulation also needs to be carried out for a long time. Some engineering college students have a great deviation in their learning attitude and learning motivation. They do not correct their learning attitude. Their learning motivation only depends on the assignments or rewards assigned by engineering teachers or internship tutors to learn their professional knowledge, resulting in problems such as weak professional knowledge system, imperfect knowledge system, lack of learning in place and so on. The attitude





of college engineering students towards lifelong learning urgently needs the correct guidance of engineering teachers. With the increasing maturity of China's engineering technology, such as ship technology and bridge construction technology, these projects and corresponding technologies also move towards the international community, which requires colleges and universities to cultivate the crisis handling ability and international exchange and cooperation ability of engineering students. The cultivation and promotion of comprehensive quality requires long-term planning and systematic cultivation in Colleges and universities, and its training process is also constantly developing and changing(Chen,2019).



d.Engineering Consciousness.Engineering consciousness is one of the important components of engineering quality elements. Engineering consciousness refers to the general name of psychological processes such as the understanding of engineering people and engineering community on the essence, characteristics and social role of engineering, as well as their attitudes, views and ideas towards engineering activities and engineering objects. Engineering consciousness is changing dynamically with the development of engineering practice and the times. The innovative design,research and develop the project first form the main idea to be designed in the mind of the engineering designer, and carry out the innovative design on this basis, that is to say, we must have the engineering consciousness in the mind before we can put the idea into practice. Cultivating engineering spirit and engineering consciousness of





engineering students in Colleges and universities plays an incentive, regulating and guiding role in engineering students' learning and engineering practice. It is one of the necessary engineering qualities for engineering students. Under the influence of the development trend of the concept of large-scale engineering, in the face of complex engineering construction projects, engineering students should slowly accumulate and have the corresponding modern engineering spirit in the learning process of the University. Understand the specific connotation of the engineering spirit, and memorize it. When engineering students come to work, facing the engineering projects delivered by enterprises, they should consciously or unconsciously soften the modern engineering spirit into the engineering projects they design and build in the process of team cooperation. For example, when building different styles and types of venues, designers should integrate the local economy, characteristics and cultural connotation to make rich ideas, so as to form the specific picture of the project in their mind. Correctly using modern engineering consciousness to know their own engineering practice activities can enrich their own engineering practice activities, fully soften with local folk customs and local characteristics, and creatively serve the continuous development of local economy and society. Building high-quality, high-standard and high-quality projects requires correct engineering consciousness as a guide. Cultivating scientific modern engineering consciousness and engineering spirit is also an inevitable requirement for enriching and developing engineering culture(Jesiek, 2020).





e.Engineering Ethics.Engineering ethics is the moral principle that engineering technicians should abide by in the whole process of engineering activities rules and codes of conduct (Chen, 2022). In the Book Engineering Ethics: concepts and cases written by Harris et al., it is clearly mentioned that "engineering ethics is a kind of professional ethics, which must be distinguished from personal ethics and a person's ethical responsibility as other social roles" (Harris et al., 2006). When engineering students are engaged in specific engineering projects, they will have such questions in their minds: the significance and value of the construction of the project, the specific impact on local production and life, and what positive impact the project will bring to the local society after the construction is completed.How to weigh the pros and cons in the process of project construction and so on. The proposal and consideration of these problems reflect the code of conduct and industry ethics of the industry. In the process of project construction, it may bring great inconvenience to the production and life of local residents, so how to reduce this problem requires colleges and universities to cultivate the corresponding engineering ethics quality of engineering students. Engineering feelings in the project construction can make the project construction personnel regard the project construction as a systematic project, comprehensively combine the economic, social and other conditions, collect the resources of relevant parties, minimize the waste of engineering resources, save and reduce the project cost. The engineering ethics training of engineering students is a systematic project. It is far from enough to rely on the curriculum training of colleges



and universities. It also needs to be closely combined with the production practice to make engineering students internalize and externalize engineering ethics in the process of "practical learning".

The ethical quality of large-scale engineering talents requires that they can apply the engineering ethical knowledge to the engineering practice under the big background and environment. The cultivation of engineering ethics quality of engineering college students should be comprehensive. We should not only instill engineering ethics in the classroom to let students understand engineering ethics, but let students actively participate in the whole process from cognition to practice of engineering ethics in the whole relevant industry or field, so as to form a good interaction between teachers and students in the classroom, experience and perceive the real engineering environment after class. Higher engineering education should cultivate students' new engineering concepts such as ecological construction concept and sustainable development concept, as well as humanistic cultivation of the whole industry. The formation of ethical quality of large engineering talents is a whole process of systematic training, which should run through the whole system of talent training.



1.9.5 DLT

The DLT in this study is a platform that includes various Pocket Laboratory Tools(PLT), software tools, and various devices, which is a portable laboratory tool and an innovative laboratory concept that has developed in recent years. Usually in the form of a small device that can be easily carried and used. Used to support teams around the world in designing, applying and sharing scientific experiments (Mazzei & Bonanno, 2020). It integrates various sensors, measuring instruments and data acquisition equipment, enabling students to conduct scientific experiments and data collection anytime and anywhere.



DLT are typically operated and data-analyzed by means of specific programs or software platforms, and they are linked to devices like computers, tablets, smartphones, and ILE.(Chen et.al., 2020). This tools are designed to provide practicality, flexibility, and convenience to enhance students' experimentation and learning experience in science, engineering, and other related fields. Through DLT, students can conduct various experiments, measurements, and data analysis, explore scientific principles and phenomena, and develop scientific inquiry, problem-solving, and innovative thinking skills (Gereige et.al., 2020).





DLT solve the time and space limitations of traditional laboratories, stimulates students' interest in independent learning, improves students' innovative awareness and ability, and helps students develop individually (Yang, 2023). The DLT can provide students with opportunities to fully use their brains and hands-on, stimulate operational interest in thinking, and transform the form of receiving knowledge into active receiving. By learning and using DLT, students can cultivate their engineering awareness and engineering ethics, develop their creative thinking, and improve their learning ability. When the experimental project is implemented, cooperate with the team to improve the cooperation ability (Peng & Chen, 2021). These DLT provide students with the convenience to conduct experiments, explore engineering concepts, and apply theoretical knowledge in the comfort of their dormitory or living space, complementing the shortcomings of traditional laboratories and enhancing the overall learning level of engineering students.

Unlike traditional laboratories, DLT do not require extensive physical space, nor do they require expensive instruments and equipment, which can greatly reduce laboratory preparation (Romano et.al., 2019). The development of DLT provide students with more opportunities to contact with practice, and promote the innovation of experimental teaching and the development of personalized learning.





1.9.5.1 Development of DLT

The DLT are small, portable handheld experimental instrument developed by the team of Clifotn Roozeboom in the United States in March 2015 (Dan, 2015).

In 2016, Chinese engineering education officially joined the Washington Agreement, an international agreement for mutual recognition of undergraduate engineering degrees. Under the background of engineering professional certification and the construction of new engineering disciplines, DLT came into being (Zhu&Zhang, 2020).



The educational concept and research ideas of DLT conform to the training requirements of engineering professional certification for engineering students and the training mode of new engineering talents. It pays attention to the training of students' comprehensive engineering quality, realizes the functions that cannot be completed by traditional practical courses at different phases and levels, extracurricularizes some of the teaching contents in the course, opens up the theoretical teaching and practice links, and stimulates the enthusiasm of students for independent learning and collaborative learning, preliminary exploration of a new path for engineering education in local universities. Therefore, in recent years, more and more Chinese universities have chosen to use DLT for teaching. In China, Tsinghua University,



Southeast University, Harbin Engineering University, etc. (Ma et al., 2020) were the first to introduce DLT.

With the continuous application of various theoretical teaching methods, such as blended teaching, MOOCs teaching, online teaching, etc. In order to overcome the inconvenience brought by traditional teaching, some universities in China have begun to explore DLT, which have been rapidly developed and promoted.

1.9.5.2 Relationship between DLT and this Study

The DLT in this study are used as teaching aids, and do not belong to the curriculum in the strict sense. The courses involved are mainly applied to practical courses, including practical engineering skills and various experimental courses. The DLT have a positive effect on the practical guidance of engineering students, and are very convenient for students to use for secondary development. Using DLT for teaching not only broaden the thinking of engineering students, increase the fun of the classroom, but also mobilize students' enthusiasm for learning. And it makes it easier for engineering students who need to practice frequently to carry out hands-on experiments, verify theoretical learning through practical learning, and truly integrate

theory and practice flexibly. It can also make up for the limitations of time and space in traditional laboratories and the lack of experimental boxes and experimental instruments (Que, 2019), giving students greater flexibility and stimulating students' interest in independent learning. It is helpful for the individualized development of students, improving students' innovation awareness, hands-on experiment ability, communication and collaboration ability, engineering awareness and engineering ethics, so as to improve the engineering quality of engineering students.

1.9.6 MOOCs

MOOCs stand for Massive Open Online Courses. It is an online course aimed at unlimited participation and open access via the internet. In a MOOCs, course materials are typically provided digitally, including videos, readings, quizzes, and discussion forums, allowing learners to engage with the content at their own pace and convenience. MOOCs are often developed by universities, colleges, or other educational organizations and are characterized by their scalability, allowing thousands or even tens of thousands of students to enroll simultaneously. These courses are usually offered free of charge, although some platforms may offer certificates or credentials for a fee. The primary goals of MOOCs are to democratize

education, increase access to high-quality learning resources, and facilitate lifelong learning opportunities for individuals worldwide (Lan & Hew, 2020) .

The MOOCs course has successfully achieved a high-end knowledge exchange. It can be applied to expert training, interdisciplinary exchange learning, and special education learning modes any type of learning information can be disseminated through the internet. And online classrooms can bring many benefits, allowing everyone to access resources from prestigious universities for free, and to learn from anywhere and on any device, which is the value of MOOCs(Suanpang et al., 2021).

1.10 Limitations of the Study

The DLT in ILE provide new thinking and vision for deepening the engineering quality training of engineering students. However, there are also some limitations.

Firstly, The scope of this study is the learning of engineering students majoring in Electronic Information Engineering based on DLT practical courses. Given the increasing emphasis on practical abilities of engineering students, researchers have intentionally chosen this specific topic as the focus of their research. However, this

study can also be applied to other engineering majors, so participants can be recruited from other majors.

Secondly, due to limited research time, the teaching time is limited to the one semester period arranged according to the syllabus, which makes it impossible for researchers to conduct further research on the study.

Finally, the students who participated in this study were only representative of the population they were sampled from, not representative of all students. Ideally, it should be purposeful to select different groups of people including other factors such as age, gender, and learning background to ensure more comprehensive coverage.

1.11 Significance of the Study

Modern society is changing with each passing day under the active construction of engineers, which plays a vital role in the development of society and the progress of science and technology. Therefore, vigorously developing higher engineering education and cultivating high-quality engineering students is a change in the development of higher engineering education from focusing on quantity to emphasizing both quantity and quality. This study expounds the core idea of



modern engineering quality, analyses the current situation, objectives and value of engineering students' engineering quality training, and thinks about how to improve the engineering quality of engineering students from the aspects of teaching philosophy, teaching mode, teaching system, etc. The training of the school provides new thinking and vision, so as to cultivate more outstanding engineering talents for the society and the country.

This study, through an in-depth analysis of the shaping and improvement of engineering students' engineering quality in ILE, will help researchers in related fields to reflect on themselves. Associate research questions with actual needs and conduct critical reflections to clarify what kind of engineering quality should be possessed by engineering students in the era of "new engineering", and enrich the theories of new engineering talent cultivation on the basis of traditional talent training; what's more, through the DLT, the channel of ILE and quality training of engineering students has been opened up, the methods of quality training of engineering students have been expanded, and the practical significance and practical functions of DLT have been enhanced. To a certain extent, it is helpful to enrich the DLT to provide reference and help for higher engineering education, even secondary education, primary education and other fields of teaching activities and ILE integration research.



1.12 Summary

Based on the research background, this chapter discusses the problem of upgrading the quality of Chinese engineering students. Through the collection and study of some literature reviews on engineering students' engineering quality, it can be concluded that the improvement of engineering students' engineering quality plays a very important role in the development of national science and technology.

How to improve the engineering quality of engineers requires the use of appropriate strategies. According to various research results, due to the development of society, China has now entered the era of information technology. To improve the engineering quality of engineering students, the first thing is to change the training methods of engineering students. For example, use intelligent learning to replace traditional teaching methods, and use DLT that can be learned and used anytime and anywhere to change the training method that can only be practiced in traditional laboratories. However, while these approaches are known to improve engineers' engineering quality, few studies have combined ILE and DLT for engineers to demonstrate the impact of engineering quality. Therefore, this study aims to investigate the impact of DLT on the engineering quality of Chinese engineering students under ILE.