RESEARCH ON INFLUENCING FACTORS OF COLLEGE STUDENTS' ONLINE LEARNING EFFECTIVENESS AND SATISFACTION BASED ON THE STRUCTURAL EQUATION MODEL

YANPING DAI

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วิทยานิพนธ์ฉบับนี้เป็นงานวิจัยที่เกิดจากการค้นคว้าและวิจัย ขณะที่ข้าพเจ้าศึกษาอยู่ใน
คณะครุศาสตร์อุตสาหกรรม มหาวิทยาลัยเทคโนโลยีราชมงคลธัญบุรี ดังนั้น งานวิจัยในวิทยานิพนธ์
ฉบับนี้ถือเป็นลิขสิทธิ์ของมหาวิทยาลัยเทคโนโลยีราชมงคลธัญบุรี และข้อความต่าง ๆ ในวิทยานิพนธ์
ฉบับนี้ ข้าพเจ้าขอรับรองว่าไม่มีการคัดลอกหรือนำงานวิจัยของผู้อื่นมานำเสนอในชื่อของข้าพเจ้า

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....
(Mrs.Yanping Dai)

Dissertation Title	Research on Influencing Factors of College Students' Online Learning Effectiveness and Satisfaction Based on the Structural Equation Model
Name-Surname	Mrs. Yanping Dai
Program	Vocational Education
Dissertation Advisor	Assistant Professor Tiamyod Pasawano, Ed.D.
Academic Year	2023

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ABSTRACT

Online learning, as a way of learning, has shown its increasing influence in today's rapid development of science and technology and the Internet. Online education is an important engine for China to realize its education modernization and develop into a modern education power.

The stage of higher education is an important stage to train professional workforce. It is of great practical significance to study college students' online learning satisfaction to construct online courses and improve online education quality. Based on constructivist learning theory, blended learning theory, educational communication theory, and distance learning interaction theory, this research identified three potential variables of college students' online learning effectiveness and satisfaction based on literature research. Knowledge construction, teacher-student interaction, and information processing were hypothesized to construct an initial model of factors influencing college students' online learning effectiveness and satisfaction. Based on the empirical study of the structural equation model, 32 observed variables were established, and a questionnaire was designed according to the observed variables and was then evaluated by experts to obtain the formal questionnaire. The questionnaire consisted of questions about learning resources, independent learning, teacher input, communication and interaction, platform quality, independent learning, online skills, learning effectiveness, and learning satisfaction. The participants were 389 online college students from different schools and different majors who had studied online for over a year on the MOOC online learning platform of Chinese universities, selected using purposeful random sampling. SPSS24.0 was used for statistical analysis of the data, and AMOS24.0 was used to test, modify, and establish the final influencing factor model.

Based on the research conclusion, the study offers some inspirations from the perspectives of teachers' role positioning in students' learning process, students' information processing and knowledge construction ability training, course resource construction and course design, information software and hardware construction, and external environment support to provide useful references for improving and enhancing students' online learning effectiveness and satisfaction.

Keywords: online learning, learning effectiveness, structural equation model

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At this important moment when I am about to finish my doctoral program, I am deeply immersed in emotion, reflecting on this enriching and valuable learning experience, and full of gratitude for the support and encouragement I have received. I would like to take this opportunity to express my gratitude in more words.

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Dear tutors, classmates and family, I would like to take this opportunity to once again express my deep gratitude. Your support and help are valuable assets for my academic career and my future life. In the coming days, I will move forward bravely with a grateful heart and continue to write my own chapter of life. Thank you again for your continued support and encouragement.

Yanping Dai

Table of Contents

Table of Contents(Continued)

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

1.1 Background and Statement of The Study

With the rapid development of network technology, the cloud-based online learning platform for college teaching resource sharing has realized the sharing of various high-quality teaching resources. In 2015, Chinese Premier Li Keqiang proposed the "Internet +" action plan for the first time. Subsequently, the "Internet + education" model has gradually taken shape and developed rapidly. In same year, the Ministry of Education of China issued the Opinions on the Strengthening the Application and Management of Online Courses in Higher Education, which set out a series of specific requirements on the construction, application, promotion and introduction of online courses and the management system of online learning (Ministry of Education, 2015). The Key Points of Education Informatization Work in 2017 clearly pointed out that "deepening the development and application of digital educational resources" and "strengthening the breadth and depth of application of online learning space" (Ministry of Education, 2017). In 2018, China's Ministry of Education officially issued the "Education Informatization 2.0 Action Plan" to promote the vigorous development of "Internet + education" (Ministry of Education, 2018). In China's Education Modernization 2035, "Improving the investment support system for education modernization" is also taken as an important safeguard measure to achieve the goals and tasks of education modernization (Ministry of Education, 2019). At present, the integration and sharing of high-quality teaching quality in colleges and universities helps improve the quality of China's higher education, and online education is an important engine to promote China's education modernization and high-quality development of China's education.

On August 31, 2022, the China Internet Network Information Center (CNNIC) released the 50th Statistical Report on China's Internet Development Status in Beijing. According to the report, as of June 2022, the number of Internet users in China was 1.051 billion, and the Internet penetration rate reached 74.4% (CNNIC, 2022). Among such a large number of Internet users, students are still the largest group of Internet users in China, accounting for 25 percent.

Many universities around the world have suspended offline teaching during the COVID-19 pandemic. In order not to affect the students' learning process, the Chinese Ministry of Education has put forward the call for "continuous teaching and suspension of classes". According to the Survey and Analysis Report of College Students' Online Learning during the Epidemic Period released by Xiamen University Teacher Development Center, 97.1% of 118,191 college students surveyed in 334 universities in China participated in online learning (Xiamen University Teacher Development Center, 2020). "It is the first time in the history of Chinese higher education that online teaching has been launched on a large scale in Chinese universities." In recent ten years, with the

9

rapid development of information technology and the Internet, online learning has become an important means for college students to acquire knowledge and master skills.

College students are an important group of online education and online learning, and they are the main force of online learning. Online learning has brought a revolutionary new way of learning with its characteristics of flexibility, convenience, no limitation of time and space, strong interactivity and rich resources. Online learning has become an important choice for college students. Online learning is a typical product of the combination of Internet technology and education, and its educational quality has always been a hot issue concerned by the education circle, which is closely related to the effect and quality of students' online learning investment. Efficient learning effect is the goal that educators, learners and educational researchers pursue unremittingly. In this context, the research on the influencing factors of online learning for college students highlights the value and significance of the research.

Online learning effectiveness and satisfaction refers to the judgment of college students on the learning effect they feel after experiencing online learning, which comes from the relative relationship between expectation and result, and is the value judgment and evaluation of online learning. In-depth research on the effectiveness and satisfaction of college students online learning is helpful to understand the current situation of college students online learning.

1.2 Research of Objectives

1.2.1 Literature research method to determine the influencing factors of college students' online learning effectiveness and satisfaction.

1.2.2 With the help of relevant theoretical basis, build a factor model that affects the effectiveness and satisfaction of college students' online learning. On the basis of structural equation model analysis and empirical research, the paper analyzes the interaction path, the degree of relationship and the influence mechanism between each influencing factor and online learning effectiveness and satisfaction.

1.2.3 According to the problems found in the research, strategies to improve the effectiveness and satisfaction of college students' online learning are proposed from the aspects of knowledge construction, teacher role and information processing. It provides practical reference value for the sustainable development of online education in China.

1.3 Research Questions and Hypothesis

1.3.1 This paper focuses on the following issues:

1.3.1.1 Does knowledge construction affect students' learning

effectiveness and satisfaction in online learning? What are the key factors affecting students' knowledge construction needs in online learning?

1.3.1.2 Does the role of teacher affect students' learning effectiveness and satisfaction in online learning? What is the role and impact of teacher-student interaction?

1.3.1.3 Does information processing affect students' learning effectiveness and satisfaction in online learning, and which aspects directly affect the improvement of students' information processing ability?

1.3.2 Based on literature and practical experience, this paper proposes the following research hypotheses.

1.3.2.1 Knowledge construction affects online learning effectiveness and satisfaction.

1.3.2.2 Teacher role affects online learning effectiveness and satisfaction.

1.3.2.3 Information processing affects online learning effectiveness and satisfaction.

1.4 Research Scope

1.4.1 Contents

Based on the empirical research of structural equation model, from the perspective of learners, the effectiveness and satisfaction of college students' online learning is selected as the research theme, and learners' learning needs and subjective feelings are deeply concerned. Through the research, it can provide references for the construction of online courses and the improvement of online education quality.

The research content mainly includes the following aspects:

1.4.1.1 Determine the influencing factors variables of college students' online learning effectiveness and satisfaction

Based on domestic and foreign literature research and understanding of online learning effectiveness and satisfaction, combined with constructivism learning theory, the potential independent variables set in the impact model are knowledge construction, teacher-student interaction and information processing, aiming to analyze their relationship with the two potential dependent variables of college students' online learning effectiveness and learning satisfaction.

1.4.1.2 Put forward the research hypothesis and initially build the
influencing   factor model

1.4.1.3 Empirical Research

Based on the empirical study of structural equation model, three potential variables of online learning effectiveness and satisfaction of college students were identified, and 30 observed variables were established. Based on the background of the MOOC learning platform of Chinese universities as an online learning platform, the questionnaire was designed according to the observed variables, the prediction was made, the questionnaire was revised, and the formal questionnaire was determined. College students using MOOC platform were selected as research objects to collect questionnaire data.

1.4.1.4 Data analysis, verification of hypotheses and theoretical models, and revision of models

During the prediction, SPSS24.0 was used to test the reliability and validity of the questionnaire and conduct exploratory factor analysis. At the same time, the software was used to analyze the formally collected data, and the analysis results were presented in the form of charts and expounded. AMOS24.0 was used to verify the hypothesis and model initially proposed, determine whether the hypothesis is valid, modify the final model, and analyze the action path between various influencing factors and the strength of their mutual influence.

1.4.1.5 Proposing Policies

According to the current situation and specific problems of the research, this paper puts forward some strategies and suggestions to improve the course quality, teaching quality, learning effect and online learning satisfaction from three aspects: knowledge construction, teacher-student interaction and information processing.

1.4.2 Duration

The study will be conducted in the first semester of the academic year 2023.

1.4.3 Population

1.4.3.1 The population of this paper is 389 online college students from different schools and different majors on the MOOC online learning platform of Chinese universities.

1.4.3.2 Students were selected using purposeful random sampling.

12

1.4.4 Variables

Based on the relevant research results at home and abroad, combined with constructivism learning theory, educational communication theory and distance learning interaction theory, the independent variables of influencing factors of college students' online learning effectiveness and satisfaction were preliminarily determined as knowledge construction, teacher-student interaction and information processing. The dependent variables were the learning effectiveness and satisfaction of online learning.

1.4.4.1 The observed variables corresponding to knowledge construction are: learning resources, autonomous learning and teacher input.

1.4.4.2 The observed variables corresponding to teacher-student interaction are: communication interaction and teacher feedback.

1.4.4.3 The observed variables corresponding to information processing are: technical support and online skills.

1.4.4.4 The observed variables corresponding to learning effect are: learning time and learning effect.

1.4.4.5 The observed variables corresponding to learning satisfaction are: online learning, mixed online and offline learning, and offline learning.

1.4.5 Location

The research will take place at Beijing City University in China.

1.5 Definition of Terms

1.5.1 Online Learning

There are a lot of expressions about Online Learning in foreign countries, including "online Learning", "ComputerAssisted Learning", "E-learning" and so on. Anderson T and Elloumi F defined online learning as: students use the Internet to obtain learning materials, interact with teachers and other learners in teaching content, and obtain support in the learning process so as to obtain knowledge. Building personal meaning and growing through the learning experience (Anderson T & Elloumi F, 2003). This perspective emphasizes the interaction between teachers and students and between learners and resources. Online learning, online course and e-course in Chinese, e-learning, web based teaching, web based training, the training based on web technologies and On-line in English training and other terms are used by researchers to refer to online learning. The Sloan Consortium defines an online course as one in which at least 80% of the content is done online (Sloan Consortium, 2022). Online learning refers to a new way of teaching

that uses Internet technology to disrupt traditional learning models. Online learning can not only meet the individual needs of students, but also further stimulate the learning motivation of learners, and meet their learning goals at any time, anywhere, regardless of time and space restrictions (Wu Junsheng, 2014). Professor Peng Wenhui defines online learning as the behavior of college students and other learners using mobile phones, computers and other electronic devices to independently carry out long-distance online learning in the learning environment created by modern technology with online interaction mechanism and abundant learning resources (Peng Wenhui, 2013). Marshal argues that online learning refers to the way that learners carry out online learning behaviors driven by specific learning goals. Learning goals, which can be set by others such as the school or the teacher, or independently, are a collection of various explicit and implicit behaviors manifested in the learning process (Marshal, 2011). Wei Jintao once defined online learning as a way to independently carry out online learning in a network virtual learning classroom by using mobile phones, computers and other wireless networks or the Internet. Online learning takes the initiative to acquire knowledge as the intention, learners as the main body, lecturers as the leading, teachers and students interaction as the main feature of the teaching platform, and independent learning, homework submission, group discussion, mutual assistance, interaction, teaching evaluation as the main content form (Wei Jintao, 2019).

Online learning in this study refers to the process in which students learn online courses through network, which are provided by specific educational organizations (universities) with integrated application of network distance technology and platform, and account for 80% or more of the total educational teaching activities to achieve the teaching objectives in the subject field.

We believe that online learning is a new learning mode in which learners acquire rich learning resources in the online learning space, form an online learning community through the interaction between teachers and students, students, teaching content and teaching media, and then actively construct the meaning of knowledge and achieve the learning goal.

1.5.2 Learning Effectiveness

Learning effectiveness is the synthesis of learners' learning behavior and the ratio of learning result to the comprehensive learning cost paid for realization, that is, the comprehensive learning result of unit learning cost (Sammons,P.,1995; Dusick,D.M.,1998; Bourne,J.,2000; Sexton,M. B.,2003; World Bank,2003, et al).

From the above definition, it can be seen that the first level of learning effectiveness is the comprehensive learning outcome. The basic evaluation factor of learning effectiveness is whether students have achieved their learning objectives, that is, to evaluate students' learning development, mainly the degree of knowledge and ability development. Of course, students' emotional development is also one of the factors.

Another level of learning effectiveness is the comprehensive cost of learning, including learning time, learning energy input and so on. From the elements of learning effectiveness, we can see that the study of learning effectiveness requires us to pay attention to the cost of learning while studying the learning outcome.

Learning effectiveness is related to each learner and teacher. In education and teaching, from the perspective of teachers, what learners learn in the teaching process is called learning effectiveness. From the perspective of learners, all the knowledge, ability and values that learners gain in the learning process are called learning effectiveness.

The learning effectiveness mentioned in this study refers to the gain and improvement of learners' knowledge, ability and accomplishment in the learning process. As for the measurement dimension of learning effectiveness, the researchers analyzed relevant literatures and synthesized the views of scholars. The measurement dimension of learning effectiveness in this study mainly focuses on the three dimensions of learners' basic knowledge, key ability and comprehensive accomplishment.

1.5.3 Online Learning Effectiveness

Online learning effectiveness refers to the learner's learning gains in the process of online learning. At present, most researchers simply take the learning performance or satisfaction of learners in the process of online learning as the measurement standard, and pay little attention to learners' own ability and comprehensive quality, and fail to properly pay attention to the improvement of learners' comprehensive quality, and pay insufficient attention to learning itself.

The effectiveness of online learning mentioned in this study refers to the learning effectiveness of learners in the process of online learning, so the effectiveness of online learning is defined as: the basic knowledge, key abilities and comprehensive literacy acquired by learners through online learning; Basic knowledge mainly refers to the knowledge learners should master through online learning, including subject-related concepts, research methods, cutting-edge knowledge, etc. Key abilities mainly refer to the abilities that learners can master through online learning, such as the ability to use information tools mastered through online learning, the ability to learn independently through online interaction, and the ability to cooperate in inquiry. Comprehensive literacy mainly refers to the improvement of learners' own literacy during online learning. For example, learners improve information literacy through online learning, media literacy, ideological and political literacy through the use of information tools, and so on.

1.5.4 Satisfaction

This study believes that learning satisfaction refers to the different degrees of satisfaction or pleasure generated by learners according to the gap between

expected gain and actual effect, and is a visual description of learners' subjective feelings about the learning process.

"Satisfaction" originated in the field of management and is mainly used to evaluate consumers' satisfaction with the purchased products and services, namely "customer satisfaction". In recent years, interdisciplinary development has become a major trend in the academic world. More and more scholars apply the concept of satisfaction to the field of education, taking students as consumers and educational courses and other content as products. Therefore, learners' satisfaction should be fully considered in the process of teaching design and application.

1.5.5 Learning Satisfaction

A foreign scholar Tough proposed the concept of learning satisfaction earlier. In his opinion, learning satisfaction refers to students' subjective feelings of various elements in the whole learning process. Such feelings or attitudes come from the degree of satisfaction of students' needs and wishes, which can be divided into satisfaction and dissatisfaction (Tough, 1985). The viewpoint proposed by Chinese scholar Yu Wenhao also focuses on describing students' subjective feelings. He believes that learning satisfaction refers to their feelings about the curriculum system and the quality of resources, which can be divided into positive and negative ones (Yu Wenhao, 2013). According to Wen Jing, learning satisfaction is the experience and judgment of the whole teaching process, which can reflect the learning quality of students and the teaching level of the school (Wen Jing, 2019). Wang Chun believes that in online education, learning satisfaction refers to the relative relationship between learners' expectations of whether they can learn knowledge in advance and the actual feeling they get after the actual learning process. It refers to a psychological sense of accomplishment and pleasure, and their demand for knowledge is met during and after the learning process. In order to obtain learning satisfaction, Take an active part in the learning process (Wang Chun, 2014). Wei Huafei, on the other hand, defined learner satisfaction as the inner feeling of happiness or disappointment when learners compare learning gains with learning expectations (Wei Huafei,2005).

1.5.6 Online Learning Satisfaction

We believe that online learning satisfaction refers to students' subjective evaluation of multiple teaching elements such as media technology, teaching resources and teaching interaction according to their personal learning needs in the learning process supported by modern information technology. If the learners have a positive attitude or sense of pleasure in the process of online learning, they have a high degree of online learning satisfaction; On the contrary, if the learners' learning needs are not met or they have negative learning feelings, then they have lower online learning satisfaction.

To sum up, students' learning satisfaction is their subjective feelings about the evaluation of things. In this study, satisfaction in the field of economic management is introduced into the field of online education, and learning satisfaction is defined as the sense of satisfaction or disappointment generated by the comparison between learners' perception of knowledge construction, teacher role and information processing in the process of online learning and their expectations before learning.

1.5.7 Structural Equation Model (SEM)

Structural Equation Model (SEM) is a method for building, estimating, and testing causal models. The relationship between variables is analyzed based on the covariance matrix of variables, so it is also called covariance structure analysis. The structural equation modeling adopts a posteriori logic, that is, according to the previous research experience, the hypothesis constructs the network structure model. After the construction of the model is completed, the overall fit of the model is tested to determine whether each path in the model is significant to determine whether the model is available, and then the influence of independent variables on dependent variables is determined one by one.

Structural equation modeling (SEM) is a multivariate statistical method used to analyze the relationship between variables. It is a multivariate linear statistical modeling method, and its analysis process includes model construction, model correction and model interpretation. The variables in the model can be divided into potential variables and observed variables, in which the observed variable is the variable that can be measured directly, and the potential variable is the variable that cannot be measured directly but can be measured indirectly with the help of the observed variable. Structural equation model can not only measure the reliability and validity of the scale, but also find the influential factors and clarify the relationship between the influential factors, which has an incomparable advantage of traditional regression analysis. Therefore, structural equation model is very suitable for the study of influencing factors and influencing paths of college students' online learning effectiveness and satisfaction. Structural equation model consists of two basic models: measurement model and structure model. Observation model is mainly used to analyze the relationship between potential variables and observed variables. In this study, it is mainly used to analyze the relationship between potential variables such as knowledge construction, teacher-student interaction, information processing, learning effectiveness and learning satisfaction and corresponding observed variables. The structural model is mainly used to discuss the relationship between potential variables. In this study, it is mainly used to discuss the internal relationship between potential variables such as knowledge construction, teacher-student interaction, information processing, learning effectiveness and learning satisfaction.

1.6 Expected Benefits

1.6.1 Understand the current status of college students' online learning effectiveness and satisfaction.

1.6.2 Determine the influencing factors of college students' online learning effectiveness and satisfaction.

1.6.3 Establish the factor model and influencing mechanism of college students' online learning effectiveness and satisfaction.

1.6.4 Put forward countermeasures to improve college students' online learning effectiveness and satisfaction.

1.7 Conceptual Framework
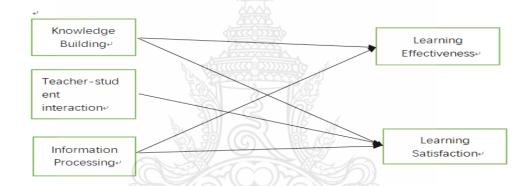
Figure 1 Conceptual framework of influencing factors of college students' online learning effectiveness and satisfaction

CHAPTER 2
REVIEW OF THE LITERATURE

The objectives of this chapter complement the introduction. This chapter will further contribute to the literature review in the process of research design, and determine the influencing factors of college students' online learning effectiveness and satisfaction based on the empirical study of structural equation model. This chapter is divided into the following parts:

2.1 Online Learning

    2.1.1 Definition of online learning

    2.1.2 Features of online learning

    2.1.3 Research on online learning

    2.1.4 Advantages and limitations of online learning

    2.1.5 Curve trend of online learning

2.2 Learning Satisfaction

    2.2.1 Definition of learning satisfaction

    2.2.2 Structure of learning satisfaction

    2.2.3 Measurement of learning satisfaction

    2.2.4 Literature review on learning satisfaction

2.3 Research status of online learning satisfaction

    2.3.1 Research status of online learning satisfaction in China

    2.3.2 Research status of online learning satisfaction abroad

2.4 Structural Equation Model

    2.4.1 Definition of structural equation model

    2.4.2 Introduction to structural equation models

    2.4.3 Basic principles of structural equation model

    2.4.4 Modeling steps for structural equation models

    2.4.5 Advantages of structural equation model

    2.4.6 Application of structural equation model in management research field

2.5 Relevant Theoretical Research

2.5.1 Constructivism learning theory

2.5.2 Blended learning theory

2.5.3 Educational communication theory

2.5.4 Interaction theory of distance teaching

2.5.5 Theoretical basis and analytical framework of this paper

2.1 Online Learning

2.1.1 Definition of online learning

With the rise of knowledge economy, the learning mode we are familiar with is facing unprecedented impact. The characteristics of the knowledge economy, such as the explosion of information and the rapid updating of knowledge, have prompted people to seek more flexible and efficient learning methods to adapt to the changing knowledge needs. In the context of this era, a learning model with a revolutionary impact has emerged, that is, networked learning, also known as online learning. Online learning uses network technology and education platform to enable students to learn in a virtual environment, realizing the goal of unlimited region, rich and diverse learning resources and personalized learning. However, this way of learning also brings new challenges, especially for college students. They need to develop the ability to learn independently, manage their time wisely, and master the use of technological tools. Therefore, it is crucial to understand the factors that influence the effectiveness and satisfaction of college students' online learning. Previous studies have shown that learning motivation, learning habits, technical literacy, teaching quality and other factors may have an important impact on college students' online learning experience. In this study, we will use structural equation model to deeply explore how these factors affect college students' online learning effectiveness and satisfaction, so as to provide empirical support and valuable enlightenment for adapting to the learning needs of the era of knowledge economy.

The term online learning is indeed very rich, and different cultures and contexts may use different terms to describe similar learning styles. Anderson T and Elloumi F's definition highlights key elements of online learning, including students' use of the Internet to access learning materials, interact with teachers and other learners, and receive support to promote knowledge acquisition and personal growth. This definition particularly emphasizes the importance of interaction in online learning.

In Chinese, terms such as "online learning", "online course" and "online course" are often used to refer to online learning. And in English, "E-learning", "Web-based teaching"," Web-based training", "the training based on web technologies", "on-line" Words like "training" can be used to describe online learning.

The Sloan Consortium's definition is more specific, stating that at least 80 percent of an online course must be completed online. This definition emphasizes the proportion of online learning in the delivery of course content, indicating that the majority of learning activities are conducted online.

These different terms and definitions reflect the diversity and evolution of the field of online learning. Whichever term is used, it highlights the important role of the Internet and technology in education and the criticality of the interaction between learners and learning resources for a successful online learning experience.

The definition of online learning proposed by Marshal (2011) emphasizes the ways in which learners engage in online learning driven by specific learning goals. This definition highlights the goal-oriented nature of learning, indicating that online learning is a learning behavior undertaken in order to achieve clearly defined learning goals. It is important to note that these learning goals can come from a variety of sources, including schools, teachers, or learners themselves. This perspective highlights the flexibility of online learning, where learners can set learning goals based on their own needs and interests, rather than just being set by others. This means that the online learning pathway can support a variety of explicit and implicit learning behaviors, thus forming a collection of various activities and behaviors in the learning process. The value of this definition is that it treats online learning as a personalized and goal-oriented way of learning that emphasizes the active participation and autonomous decision-making of learners. This helps to understand the diversity of online learning, as learners can choose the learning style and resources that suit them according to their own needs and goals. This also highlights the flexibility of online learning as an educational tool, able to adapt to different learning situations and needs.

The definition of online learning proposed by Professor Peng Wenhui (2013) examines this learning style from the perspective of technology and learning environment. He described online learning as the independent long-distance network learning of college students and other learners using mobile phones, computers and other electronic devices in a learning environment built by modern technology with online interactive mechanisms and rich learning resources. This definition focuses on the role of technological tools in online learning, emphasizing that learners can access educational content through electronic devices such as mobile phones and computers. At the same time, he also highlighted the learning environment of online learning, which provides online interaction mechanisms that allow learners to interact with teachers and other learners, as well as rich learning resources that provide learners with a variety of learning materials. The value of this definition is that it highlights the critical role of modern technology in online learning, and the importance of the learning environment. It emphasizes the flexibility of online learning, where learners can use electronic devices to learn anytime, anywhere. In addition, this definition also focuses on the communication and interaction between learners, which is an important feature of online learning. With this definition, we can better understand online learning as a form of distance online learning characterized by technical support, learning environment and interaction

between learners. This facilitates in-depth research on the influencing factors and effects of online learning to better support the modernization of education and learning.

Wu Junsheng's (2014) definition of online learning highlights the subversive impact of Internet technology on traditional learning methods. He sees online learning as a new type of teaching that uses Internet technology to change the traditional learning model. This definition emphasizes two key aspects of online learning. First of all, it emphasizes the personalized characteristics of online learning, which can meet the individual learning needs of students. Online learning can be tailored to the learner's interests, learning speed and learning style to provide a personalized learning experience. Secondly, it points out that one of the advantages of online learning is to stimulate learners' learning motivation. Online learning provides a more flexible and convenient way of learning, which can be carried out anytime and anywhere, without the limitation of time and space, which helps to stimulate the active learning interest of learners. The significance of this definition is to highlight the innovative and adaptive nature of online learning. It highlights how online learning as an educational method can use Internet technology to achieve an impact on traditional learning methods, provide a more flexible and personalized learning experience, and play a role in stimulating learning motivation. Online learning has become an important trend in the field of education, helping to meet the diverse needs of learners and promoting the modernization and globalization of education.

Wei Jintao's (2019) definition of online learning emphasizes its technology, learning environment and learning characteristics. He regards online learning as a way to independently conduct online learning through a network virtual learning classroom using wireless networks such as mobile phones and computers or the Internet. This definition specifically describes how online learning is implemented. It points out that learners can learn in online virtual learning classrooms through wireless networks or the Internet, using electronic devices such as mobile phones and computers. In this virtual learning environment, learners take the initiative to acquire knowledge as the motivation, and instructors play a leading role in teaching. The definition also emphasizes the interaction between teachers and students in the online learning platform, which has become an important feature of online learning. In addition, the definition also mentions the main content forms of online learning, including self-directed learning, assignment submission, group discussion, mutual assistance, interaction and teaching evaluation. The significance of this definition is that it gives a detailed description of the specific implementation and characteristics of online learning. It highlights how online learning as a technology-enabled way of learning can be achieved through virtual classrooms and online interactions. Online learning not only focuses on the transfer of knowledge, but also emphasizes the initiative and cooperation of learners, and strengthens the interaction and participation in the learning process. This definition helps us to understand more fully the nature and characteristics of online learning.

2.1.2 Features of online learning

2.1.2.1 Online Learning 1.0 —Educators provide learning resources and deliver quality courses on portals, characterized by:

1) To impart knowledge.

2) Educator-centered.

3) Take exam-oriented education as the teaching purpose.

4) The main feature is to present learning resources.

5) Online courseware, test questions, learning materials, teaching, tutoring, training as the form of performance.

2.1.2.2 Online Learning 2.0 —Learners submit learning assignments and discuss and exchange learning content on the network teaching implementation platform, which is characterized by:

1) Focus on active exploration.

2) Learners as the main body and educators as the leading.

3) Take ability education as the teaching purpose.

4) It is mainly characterized by discussion and communication on the network platform.

5) Self-exploration, homework, interaction, mutual assistance, process evaluation as the main forms of expression.2.3 Literature review of online learning at home and abroad

In recent years, various online education platforms are gradually coming into view. In 2020, the development of online learning will be pushed to a climax during the COVID-19 prevention and control. The innovative integration of various types of information and communication technologies is making online learning more personalized, diversified, innovative and enriched. In recent years, domestic and foreign scholars' researches on online learning mainly focus on online learners' learning behavior, online learning resources, online learning activity design, online learning platforms and systems and related supporting technologies.

2.1.3.1 Study on online learners' Learning behavior

Chinese scholar Peng Wenhui et al. proposed a learning platform framework based on learners' online learning behaviors, laying a foundation for the intelligent evaluation of subsequent online learning behaviors (Peng Wenhui, 2012). With the development of modern information technology, learner's online behavior analysis is becoming more digital and precise. Hu Yiling, Gu Xiaoqing et al. established a three-level online learner behavior model with data, mechanism and result, and analyzed different types of online learner learning data (Hu Yiling & Gu Xiaoqing, 2014). By using behavior capture software, foreign researchers She H C et al collected and recorded learners' online learning operational behaviors with a time unit of 5 seconds and conducted mining and analysis to study the correlation between elements such as metacognitive strategies and learners' problem-solving ability in the process of online learning (She H C, 2012).

2.1.3.2 Research on construction of online learning resources

The content quality of online courses is the key factor to ensure the effect of online learning. Wang Weijun et al. put forward relevant improvement strategies for online learning resource construction from two aspects of online course design ideas and principles, such as simplifying course content and enhancing content practicability (Wang Weijun, 2020). Starting from a new perspective of "satisfying learners' content experience", Huang Lu et al. constructed an evaluation index for online course content quality, emphasizing on satisfying learners' knowledge needs and learning experience (Huang Lu, 2020). From the perspective of learning experience, Mi Gaolei et al designed and practiced the course "Internet Finance" (Mi Gaolei, 2017). Miftachul H and Andino M et al. built an innovative environment for online learning resources under big data technology. Specifically, it includes seven elements such as big data analysis process, maximizing potential data value, learner acquisition, improving experiential learning, integrating resources and interactive practices, innovative allocation and flexibility, the connection between resources, and students' self-regulated learning (Miftachul H & Andino M, 2018).

2.1.3.3 Design of online learning activities

Wang Xinchen et al. effectively and innovatively integrated wechat with the existing flipped classroom teaching model, and proposed the implementation strategy of flipped classroom teaching based on wechat (Wang Xinchen, 2017). Li Zhihe et al. took the network learning space as the supporting background, taking into account students' collaborative learning and independent learning, and built the activity mechanism of blended learning community (Li Zhihe, 2019). Li Song et al. classified online learning activities and discussed the strategies, methods and principles of online learning activity design (Li Song, 2010). According to the research of foreign scholar Susan KO et al., online learning activities are divided into different types, such as group collaboration, online debate, case study, role playing and reflective summary (Susan KO, 2010).

2.1.3.4 Online learning Platform and System

Liang Qingqing, Zhang Gangyao et al. designed a blockchain model based on online learning outcomes and teaching quality, and solved the drawbacks of blockchain network that data cannot be tampered with, as well as the problems of fairness and low credibility of authentication results (Liang Qingqing, 2020). As the new normal of learning today, online learning pays more and more attention to the learning experience of learners. Liu Shu experiences and analyzes eight different online learning platforms from the perspective of users, and analyzes the platform elements and functions of online learning (Liu Shu, 2019). China's online learning platforms include Fluent English, squirrel AI, Chinese university MOOC, etc., while foreign online learning platforms include Edx, Future Learn, etc.

2.1.3.5 Online learning support Technology

Chinese scholar Yang Kaicheng earlier designed and built the online learning system "Data Structure" based on the ARCS motivation model, including online learning, knowledge query, question answering and discussion modules (Yang Kaicheng, 2001). Traditional adaptive network learning system may cause the problem of loss of emotion. In 2008, Hou Fengzhi et al. formed an affective interaction module with the help of affective computing technology on the basis of the original adaptive network learning system research, and fully discussed it at the theoretical level (Hou Fengzhi, 2008). According to the research of Jiang Qiang and Zhao Wei et al., big data technology is of great value in analyzing students' learning behaviors, giving accurate and timely feedback and guiding students' personalized learning (Jiang Qiang, 2015). Foreign researchers Miftachul H and others also built a new online learning resource environment based on big data technology. The boom in 5G technology touches on further changes in education. With the help of artificial intelligence and 5G technology, Lu Wenhui outlined the framework of intelligent adaptive learning platform and discussed the important role of the platform in promoting intelligent teaching (Miftachul H, 2015).

2.1.4 Advantages and limitations of online learning

This way of online learning is a new learning environment composed of multimedia network learning resources, online learning community and network technology platform. Compared with other learning modes, it has incomparable advantages, but it also has certain limitations.

2.1.4.1 Advantages of online learning

1)Online learning It is easier to achieve one-to-one communication between learning and teaching.

2)Online learning It fully respects the student's personality and stimulates the motivation of learning

3)Online learning is not limited by time, place, and space, and can achieve the same interaction as in reality.

2.1.4.2 Limitations of online learning

1)Lack of human communication. The Internet artificially widens the distance between people and sets up obstacles for direct emotional communication. Lack of emotional communication between employees, lecturers and employees, emotional communication, the effect of learning may be greatly reduced.

2)Weak practice function. In order to truly acquire and master knowledge and technology, it is not enough to only explain through online Learning, we must personally participate in practice and apply it in the real environment.

3)Limitations in teaching content transmission. Traditional training takes place in a learning environment under the instructor's complete control, it needs to be rearranged and changed at any time, and there are many factors that affect the teaching situation such as the instructor's effort and personal ability, skills, adaptation to the teaching environment and the courseware provided. In the case of Online Learning, however, this change is not possible due to isolation from the network of trainees, resulting in a critical barrier to content.

4)Limitations in learning content. In terms of learning content, China is relatively short of high-quality, multimedia interactive online Learning courseware and platform, different interfaces, repeated registration, no standard software, and many different formats of online courses. This is not only difficult to manage, but also costly, the result is that it is difficult to establish a good communication system in the company, and the transmission of information is extremely not smooth.

2.1.5 Curve trend of online Learning

Since the first paper on LAN based training was published in the American Journal of Training in 1996, online Learning has entered a "honeymoon period" of rapid development. With the characteristics of lower cost and greater flexibility, the proportion of online Learning in all training methods of enterprises is increasing year by year, and it has nearly one-third of the training market in the United States.

However, with the rapid development of online Learning, more and more problems have emerged: the high dropout rate of online Learning learners, and many learners feel that they are not adapted to new technologies, lack of interpersonal interaction, and are prone to boredom; The lack of role-playing activities reduces the application value of learning content, and online Learning lacks advantages in the cultivation of soft skills (such as management, interpersonal communication, negotiation, etc.), so it is difficult to transform students' tacit knowledge into explicit knowledge.

2.2 Learning Satisfaction

2.2.1 Definition of learning satisfaction

The Chinese dictionary interprets the word "satisfaction" as meaning that the will is fulfilled and the desire is met. This is a pleasant feeling that comes after performing an activity and is highly subjective. Satisfaction is the degree of satisfaction, which is the level of feeling state, which comes from the respondent's comparison of the actual effect and the expectation of something. As for the concept of learning satisfaction, researchers from different backgrounds have different understandings of it. So far, there is no strict and unified definition of learning satisfaction. The researchers have made their own discussion on the learning satisfaction from the aspects of wholeness, demand achievement and factors. First, the overall significance of learning satisfaction.

Tough (1985) believes that for students, Satisfaction refers to their feeling or attitude towards learning activities. "Satisfaction" means happy feeling or positive attitude, while dissatisfaction means unhappy feeling or negative attitude. "Learning satisfaction" is the concept that one's wishes and needs are met during the learning process.

Wei Huafei(2005) defined learner satisfaction as the inner feeling of happiness or disappointment when learners compare learning gains with learning expectations. Yu Wenhao (2013) The viewpoint put forward by Chinese scholar Yu Wenhao also focuses on describing students' subjective feelings. He believes that learning satisfaction is the feelings about the curriculum system and the quality of resources, which can be divided into positive and negative. Wang Chun (2014) believes that in online education, learning satisfaction refers to the relative relationship between learners' expectation of learning knowledge in advance and their actual feelings after learning. It refers to a psychological sense of accomplishment and pleasure, and their demand for knowledge is met during and after learning. And in order to get the satisfaction of learning, actively participate in the learning process. Wen Jing (2019) believes that learning satisfaction is the experience and judgment of the whole teaching process, which can reflect the learning quality of students and the teaching level of the school.

In short, learning satisfaction mainly emphasizes a subjective feeling and attitude in the learning process. From the above definition, it can be seen that learning satisfaction is a positive feeling generated during learning activities. According to the above definition, learning satisfaction refers to learners' experience and perception of various factors affecting learning in the learning process, and the subjective feeling of satisfaction generated by comparing this perception with their previous learning expectations.

2.2.2 Structure of learning satisfaction

The emphasis of the study of learning satisfaction lies in the discussion of its structure. The academic circle has studied the dimensions of learning satisfaction from different starting points, and the results are not the same.

Langston (1989) believes that the measurement of learning satisfaction can be started from the aspects of teachers, course content, conduct methods, teaching materials, atmosphere and course quality to explore the differences in learning degree (201. In her research, Guo Xiuwei introduced six dimensions of learning outcomes, entrance education, face-to-face teaching, course content, learning environment and learning support service to measure learning satisfaction.

According to Hynes (1990). The emphasis of "learning satisfaction" mainly includes five levels: learning content, learning plan, teaching staff, teaching equipment and teaching service. Hao Jianchun from the learning environment, teaching public facilities, teacher quality and teaching equipment and teaching service five levels.

Hao Jianchun (2005) explored college students' learning satisfaction from five aspects: learning environment, teaching public facilities, teachers' quality and teaching attitude, teaching process, and interpersonal relationship. On this basis, it makes a specific interpretation: (a) learning environment includes teaching methods, teaching software and hardware facilities provided by teaching resource centers, etc. (b) teaching public facilities include various tangible or intangible teaching services and logistics support, such as school public facilities, etc. (c) Teacher quality and teaching attitude refers to students' satisfaction with teachers' professional skills, class attitude, teaching methods and explanatory ability; (d) The teaching process is the degree of satisfaction of students with the difficulty and progress of the teaching content during the learning period; (e) Interpersonal relationship refers to the degree of satisfaction students feel with their interpersonal relationships with teachers, fellow students and administrative staff in the course of learning.

When chadwick & ward (2006) studied the learning satisfaction of business students, it was divided into 48 questions from nine aspects, including: the value of study in the job market, teacher quality and teacher-student relationship, education cost, tutoring staff, tutoring employment, social life and teaching process.

Zhao Jiming (2007) also proposed four dimensions when adjusting the learning satisfaction of college students in physical education class, namely, the relationship between classmates, the ability of teachers, the equipment of venues and the evaluation of grades.

2.2.3 Measurement of learning satisfaction

Although learning satisfaction has gradually attracted the attention of the academic circle, there have been some empirical studies on learning satisfaction, but the overall feeling is disordered. Measuring tools are even more scarce. In a survey of the research on learning satisfaction at home and abroad, most of the measurement scales are designed by researchers for specific problems.

Anderson (1982) compiled a multi-dimensional model, "Quality of School Life Scale". The assessment applied to all aspects of school life is an important source of students' satisfaction in school life. The scale includes 14 areas such as curriculum, goal achievement, learning situation, personal needs, assessment, school climate, personal factors, support, relationships, objective environmental factors and subjective environmental factors. Each area has four aspects and the type of question is "How satisfied are you with this aspect of your school?" Each area contains four items, and the score for each question varies from 1 to 4, that is, from unsatisfactory to satisfactory, depending on the level of satisfaction.

Jin Xiaomiao (2006) made a study on the preparation and application of the scale of life satisfaction in primary learning, which contains 35 items and a total of 6 dimensions, respectively: Satisfaction with teachers, satisfaction with parents' learning

support, satisfaction with classmates, satisfaction with classroom learning environment, satisfaction with learning ability, satisfaction with learning support, satisfaction with classmates, satisfaction with classroom learning environment, satisfaction with learning ability, satisfaction with studies. The scale adopts five-point scoring method, and some questions are reverse scoring questions. The higher the score, the more satisfied junior high school students are with their study and life, and the lower the satisfaction is with their study and life." And Guo Xiuwei specially compiled the adult learning satisfaction scale, through face-to-face tutoring, course content, learning outcomes, entrance education, learning support services, learning environment six levels of satisfaction to explore the satisfaction of adults in all aspects.

Wu Daxing et al. (2006) conducted a survey on medical students' satisfaction with multimedia learning. The total score of the questionnaire ranged from 56 to 111 points, with an average of 85.1 points, and the total score was 3.4 points, among which the factors were 8-25 points for teaching effect, 7-25 points for learning help, 5-15 points for learning opportunities, 6-15 points for psychological feeling, and 3-14 points for learning attention. Learning motivation 4-15 points, teaching content 5-15 points.

2.2.4 Literature review on learning satisfaction at home and abroad

As for learning, learning satisfaction is an important indicator, which is the result of the comparison between the participants' actual feelings and their expectations for learning activities after completing the learning process. This result plays an important role in evaluating the quality of education and has important guiding significance for educational reform.

2.2.4.1 Literature review of learning satisfaction in China

Zhai Xuesong (2016) explored the influencing factors of flipped classroom satisfaction from seven factors, including learner expectation, face-to-face classroom interaction and learner perception, and focused on analyzing the important influence of learners' learning initiative on flipped classroom learner satisfaction. Liu Weitong et al. (2019) built a model of influencing factors of blended learning satisfaction based on the perspective of learners. Li Xian (2019) conducted a survey on college students from 9 universities in Hainan Province, and studied their satisfaction with English learning from three aspects: environment, teachers and students themselves. He found that the actual improvement of students' English scores, teachers' responsibility, teaching methods and learning atmosphere were the most influential factors. Zhang Sheng et al. (2020) took primary and secondary school students as the research object and discussed that learning satisfaction would change in stages with the increase of age and school level.

In addition, there are abundant researches on the influence of certain specific factors on learning satisfaction in China, including learners' time management tendency and learning motivation.

2.2.4.2 Literature review of foreign study satisfaction

Foreign research on learning satisfaction also includes its influencing factors.

Chadwick et al. understand students' learning satisfaction from the aspects of teaching process, education cost, and employment services (Chadwick, 2015). Betz et al. compiled questionnaires from the dimensions of campus environment, teacher quality and teaching methods (Betz,). Jaeger conducted a survey from the aspects of teachers' academic level, care for students, teaching progress and homework difficulty.

Different from China in the study of learning satisfaction, foreign studies in this area also include the compilation of scales. In 1993, the American higher education research Institute put forward the CSS(College Student Survey) assessment index to provide the basis for the study of learning satisfaction (American Higher Education Research Institute, 1993). Noel-Levitz Company of the United States published different versions of SSI(Student Satisfaction Inventory), including more than 70 items, to investigate the satisfaction of students at different levels of universities or higher education institutions (Noel-Levitz Company, 1993). The scale designed by the British Higher Education Council and related researchers measures students' learning from various aspects such as course teaching, organization and management (British Higher Education Council, 1999).

In addition to the study of influencing factors, foreign studies pay more attention to the relationship between students' and teachers' personal subjective factors and learning satisfaction, and emphasize the subjective role of learners and educators. Lagrosen et al. divided learners into external control type and internal control type and explored the differences in learners' satisfaction level (Lagrosen,2004). According to Mevetta, students' learning satisfaction is influenced by such factors as course materials, teacher-student interaction and teachers' teaching characteristics (Mevetta, 1990).

2.3 Literature Review on Online Learning Satisfaction at Home and Abroad

2.3.1 Research status of online learning satisfaction in China

According to the research of Xu Xiaoqing and Zhao Wei et al., interaction between learners, teachers and learning content as well as self-regulated learning are important factors affecting college students' satisfaction with online learning (Xu Xiaoqing, 2017). Jiang Zhihui and Zhao Chengling et al. conducted a literature study and discussed the influencing factors of online course learners' satisfaction, including learners, instructors, courses and environment (Jiang Zhihui, 2017). Learning motivation, learner self-management, course and platform design, teacher support and learner interaction also influence online learning satisfaction. Table 1 shows the variables established by other domestic learners, such as Zeng Jialing, Xu Xiaoqing, Zhao Wenjun

and Shen Zhonghua, on the influencing factors of online learning satisfaction.

Table 1 Influencing factors and variables of online learning satisfaction in China

Domestic scholars	Year	Factors influencing online learning satisfaction variables
Zeng JiaLing，Lu Xinger, Yang , Wu Xiuhan ,Zheng Qinhua	2016	Learning ability, Learning process, Learning motivation, learning difficulties
Xu Xiaoqing, Zhao Wei,Liu Hongxia	2017	Interaction(between teachers and students ,students and learners and learning content) Internet self-efficacy, self-regulated learning
Zhao Wenjun, Zhao Chengling, Yang Hailu, Jiang Zhihui	2018	Objective quality ,perceived quality, motivation,subjective norms , perceived value
Shen Zhonghua ,Wu Daguang	2020	knowledge construction, teacher-student interaction ,information processing

2.3.2 Research status of overseas online learning satisfaction

The continuous development of education model also makes the research direction of online learning satisfaction more extensive. In 1970, M. Tankari. Conducted research to understand learners' perceptions of collaborative learning, social presence, and satisfaction (Tankari, 1970). The study takes CMC(computer-mediated Communication) learning environments as its main background, focusing on the nature of social existence, collaborative learning, a sense of community, and the satisfaction that online learners experience in these environments. It is expected that students with higher level of collaborative learning have higher satisfaction with distance courses and higher perception of their own social existence. Mehmet BarisHorzum came to similar conclusions when it came to students' online study satisfaction and social presence. His study looked at 205 university students who were studying for a bachelor's degree at the University of Ankara. Explore the relationship between interactivity, structure, social presence, and satisfaction in e-learning (Mehmet BarisHorzum, 2015). It is found that there is a negative correlation between interaction dimension and course structure. The social existence of online students is positively predicted by interaction, negatively predicted by course structure, and online learning satisfaction is positively predicted by social existence. KimKS and Moore JL explored the impact of students' traits and behaviors on online learning experience and satisfaction, and collected students' demographic data, learning experience and style through online questionnaires. The results showed that, Teacher-student interaction has a significant impact on e-learning satisfaction (KimKS & Moore JL,2005). In addition, some researchers have also

conducted comparative studies on student satisfaction and learning effect between online learning and face-to-face learning. For example, Johnson S D and Aragon SR et al., through empirical research, compared the differences between online graduate courses and equivalent courses in traditional face-to-face teaching in various outcome measures, including student evaluation of teachers and course quality, course interaction, structure and support assessment, and measurement of learning outcomes. The research results show that students' satisfaction level for face-to-face learning is higher than that for online learning, and this comparative study has important reference value for the subsequent construction, development and improvement of online courses (Johnson S D & Aragon SR,2000). A study by Arbaugh JB and Duray R compared students' perceptions of study satisfaction in two web-based MBA programs and found that: The smaller the class size, the greater the flexibility of the medium, the higher the student satisfaction, and at the same time, the more satisfied experienced online students are with their medium (Arbaugh JB & Duray R, 2002). These research results have important practical value for the optimization of online education platform and the design of online courses. Table 2 lists the specific variables in other foreign studies on influencing factors of online learning satisfaction, including Sun P C, Wu,J. H., Tennyson Cole,M. The study of et al.

Table 2 Influencing factors of overseas online learning satisfaction

Foreign Scholars	Influencing variables of online learning satisfaction
Sun P C,Tsai R J, Finger G,et al.	Learners' online learning anxiety, course teacher's attitude and behavior, course flexibility, course quality, perceived usefulness, perceived ease of use, diverse assessment methods, etc
Wu Tennyson & Hsia	Cognitive level, technical environment, social environment
Cole Shelley &Swartz	Mentor, learner, course structure, technical level

2.4 Structural Equation model

2.4.1 Structural equation model definition

Structural Equation Modeling (SEM) is a method of building, estimating, and testing causal models. The model contains both visible observable variables and potential variables that cannot be directly observed. Structural equation model can replace multiple regression, path analysis, factor analysis, covariance analysis and other methods to clearly analyze the role of individual indicators on the whole and the relationship between individual indicators. Compared with traditional analysis methods, structural equation models can explain as much variation of variables as possible while understanding the covariant relationship between variables.
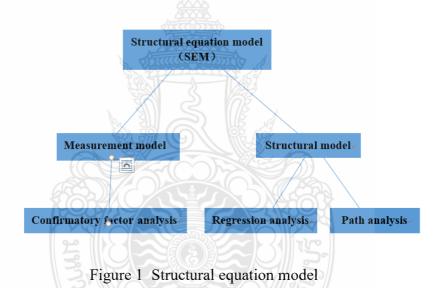
Structural equation model is a multivariate statistical method which uses linear equation to express the relationship between observed variables, latent variables and latent variables. It is a general linear model in essence.

Observed variables: variables that can be directly measured, such as a person's age, gender, etc.

Latent variables: Variables that cannot be directly measured, such as people's attitudes toward a certain behavior, feelings about certain social norms, etc

2.4.2 Introduction to structural equation model.

SEM is a statistical analysis technology including factor analysis and path analysis, which is suitable for the study of the relationship between multiple variables and has been applied in psychology, management, sociology and other social sciences. SEM consists of two basic models: measurement model and structural model.

Figure 1 Structural equation model

1) Measurement model

The measurement model represents the covariant relationship between the potential variable and the observed variable, and can be regarded as a regression model, regression from the observed variable to the potential variable. The equation can be expressed as:

$$Y_i = \Lambda \text{ omega}_i + \in_i, \ I = 1,\dots,n$$

Where, y_i represents the observation vector of $p \times 1$; A is the factor matrix of $p \times q$ corresponding tothe observation vector; ω_i is the factor score vector of $p \times 1$; $\in_i$ is a separate error term from ω_i.

33

2) Structural model

The structural model part represents the structural relationship between latent variables, and can also be regarded as a regression model, which regression several linear terms of endogenous and exogenous latent variables from endogenous latent variables. It can be expressed as:

$$\eta_i = \Pi\eta_i + \Gamma\xi_i + \delta_i, i = 1, \ldots, n$$

η_i and ξ_i are the potential variables of $q_1 \times 1$ and $q_2 \times 1$, respectively. Π and Γ represent the unknown correlation parameter matrix; $\delta_i \rightarrow$ is the error term.

2.4.3 Basic principle of structural equation model

Structural equation models typically include three matrix equations:Equations (1) and (2) are called measurement models, and equation (3) is a structural model.measurement equation describes the relationship between latent variables and indicators, such as the relationship between indicators such as work mode choice and job autonomy;structural equations describe the relationship between latent variables, such as job autonomy and job satisfaction.

2.4.4 Modeling Procedure

Analysis using structural equation models is generally divided into 4 steps:

1) Model setting: Before model estimation, it is necessary to set the initial theoretical model according to theoretical analysis or previous research results, that is, to preliminarily develop the above measurement model and structural model.

2) Model identification: In order to determine whether the set model can solve the estimated parameters, in some cases, due to the problem of model setting, the model is not recognized, such as too many coefficients to be sought and too few equations caused by too small sample size, in general, the ratio of samples to variables is more than 5:1 is more appropriate (structural equation model has higher requirements on the number of samples, When the sample size is small, the Bayesian structural equation model can be used.

3) Model estimation: Model parameters can be estimated by several different methods, the usual methods include maximum likelihood method and generalized least square method. Bayesian estimation is also often used in parameter estimation of structural equation models.

4) Model evaluation and revision: After model estimation, the overall fitting effect of the model and the estimated value of a single parameter must be evaluated.

If the model fitting effect is not good, the model can be modified to improve the model fitting effect.

2.4.5 Advantages of structural equation model

1) Multiple groups of dependent variables can be processed simultaneously

2) Independent and dependent variables are allowed to contain measurement errors

3) Can estimate the structure of factors and the relationship between factors at the same time

4) Measurement models that allow for greater elasticity

5) Can estimate the degree of fit of the entire model

2.4.6 Application of structural equation model in management research field

From the analysis of the basic characteristics of structural equation model, we can see that in the field of management research, structural equation model has a wide range of application. It is mainly reflected in the following three aspects:

1) Structural equation modeling provides a conceptual modeling and validation process for many difficult to measure concepts involved in management research.

2) Management activities are a complex system. Structural equation model can take all the information of exogenous and endogenous variables into account through the structural model of a system, and the fitted model has strong reference value.

3) Some special problems in the field of management research, structural equation model is particularly convenient to deal with.

2.5 Relevant Theoretical Research

2.5.1 Constructivism learning theory

Compared with traditional offline learning, online learning is more in line with constructivist learning theory with its characteristics of "free time and space, satisfying individual needs, strong autonomy and high frequency of interactive discussion". Therefore, in recent years, many scholars have begun to analyze the key factors affecting the effectiveness and satisfaction of online learning from the perspective

of constructivist learning theory. For example, Shang et al. believe that knowledge is constructed in activities and environments, and effective online learning requires both teachers and learners to have a strong sense of communication (Shang, 2013). Based on the constructivism learning theory, Eom constructed a research model on the influencing factors of online learning, and investigated the influence of teacher role, course design, teacher-student interaction, student-student interaction, learning motivation, etc., on students' online learning effectiveness and satisfaction (Eom, 2016).

The main point of view of this theory is that knowledge is constructed by learners themselves, rather than simply transferred from teachers, and learners grow new experience after starting from the original experience and being guided (Li Fang, 2011). The famous psychologist J.Piaget, the main representative of constructivism theory, believes that learners gradually construct knowledge about the external world in the process of "assimilation" and "adaptation" with the surrounding environment, so as to develop their own cognitive structure (J.Piaget, 1977). The so-called "assimilation" refers to the process that learners integrate the information provided by external stimuli into their original cognitive structure, which is only a process of quantitative expansion of cognitive structure. "Adaptation" refers to the process in which learners' cognitive structure changes due to the influence of external stimuli, which involves the change of the nature of cognitive structure. Learners achieve the improvement of cognitive ability and the balance with the external environment through the two forms of "assimilation" and "adaptation", so that their cognitive structure is constantly enriched, improved and developed in the process of "balance - imbalance - rebalancing". Vogotsgy, a former Soviet psychologist at the same time as J.Piaget, is also an important representative of constructivism theory. He believes that people's advanced psychological functions are not inherent in people themselves, but are generated and developed in the process of interacting with people around them (Vogotsgy, 1978). The higher psychological functions mentioned here emphasize more on people's initiative, participation and interpersonal cooperation consciousness, so Vogotsgy especially emphasizes the prominent role of activities and social communication in the development of people's higher psychological functions. He believes that interaction and participation are the

necessary conditions for the development of learners, and in the process of interaction and participation, human mental ability is thus aroused. To sum up, we can realize that the core idea of constructivism is essentially "student-centered", which emphasizes students' active exploration, discovery and construction of the meaning of knowledge. It completely subverts the traditional idea of "teacher-centered" which emphasizes knowledge imparting for a long time, and gradually forms learning theory, teaching theory and teaching design theory based on it.

2.5.2 Blended Learning Theory

Blended Learning originated from online learning and fully integrates and utilizes the advantages of online learning and face-to-face teaching (M Tankari, 1970). Students continue to learn offline while doing online learning, a phenomenon known as "blended learning" (Kim K S, 2005).The traditional curriculum learning, that is, the class teaching system, originated from the summaryand demonstration in Comenius' Great Teaching Theory, improved on the supplement and explanation of Herbart's "five-paragraph teaching method", and became famous in Erasmus, who was the first to formally use the word "class". This factory model of classifying classes according to age and taking the classroom as the basic activity place worked well in the industrial period. Cultivate a large number of skilled workers who meet the requirements of industrial production. However, in the information society where more than 60% of jobs require knowledge-based skilled workers and innovative talents, we need to constantly explore and update the new learning model with learners as the main body. Blended learning can solve the most pressing problems of controlling costs, expanding learning opportunities, and personalized learning in the three major schools (Johnson S D, 2000).

In blended learning, we should first analyze the characteristics of learners, the characteristics of courses and the actual situation, and choose the appropriate blended learning mode accordingly. Secondly, provide students with a mixture of well-structured and ill-structured learning materials, gradually increase the difficulty of problems while reducing the teaching support in the teaching process, so that students can gradually try to solve ill-structured problems through self-paced learning and

collaborative learning on the basis of understanding and solving structured and standardized problems. Finally, combining the advantages of traditional teaching and online learning environment, based on the emotional support and high-quality interaction provided by face-to-face teaching, the collection, sorting and analysis of learning data in online learning environment provides personalized learning feedback and a feasible path for capability-based learning for students.

2.5.3 Educational communication theory

Blended learning is a process of information dissemination. Educational communication theory includes educational communication information, symbol, media and effect theory. As the carrier of educational information and symbols, the choice of educational communication media has a direct determining effect on educational communication.

The word "Communication" originally comes from the English word "communication", meaning "communication, exchange, communication, etc." Educational communication is a two-way activity of information exchange between educators and educatees. There are many theories about what constitutes an educational communication system. In the book Educational Communication (Second Edition) edited by Nan Guonong and Li Yunlin, the theory of four elements is adopted, which are educators, educational information, educational media and educates (Nan Guonong and Li Yunlin, 2005), and their relationship is shown in Figure 2-1.

In the teaching process, the educator determines the educational information, chooses the appropriate educational media according to the characteristics and nature of the information to disseminate the information, and the educatees receive the information and give feedback. In the process of online learning, teachers and students interact with each other through the online learning platform to transmit and receive educational information. In this study, the latent variables of the all-influencing factor model are established based on the educational communication theory.

2.5.4 Interaction theory of distance teaching

Many scholars have put forward different views on the interaction theory of distance learning. In 1972, American distance education expert Michale G. Moore

proposed the basic framework of interaction distance theory. In the subsequent research, he introduced the element of "dialogue" into his theoretical research. In 1989, Moore proposed the theory of "three types of interaction", which divided the interaction in distance learning into teacher-student interaction, student-student interaction, and learner interaction with learning content (Michale G. Moore, 1972). In 2003, Anderson, T proposed the equivalent interaction theory, which also includes the above three interactions. He believed that in the process of distance teaching and learning, if one of the three interactions can maintain a high level, the teaching effect will be improved and students' effective learning will be promoted (Anderson, 2003). In 2004, Chinese scholar Chen Li included the interaction between learners and media into the relevant research on distance teaching interaction (Chen Li, 2004). In terms of interaction, this study mainly considers teacher-student interaction, student-student interaction, learner interaction with learning content and interaction with online learning platform. The role of interaction in online learning cannot be ignored. Therefore, according to the interaction theory of distance learning, interaction quality is considered as one of the influencing factors of college students' online learning satisfaction. When conducting online teaching, teachers should design interactive teaching activities, use simple and friendly media interfaces, and build knowledge exchange platforms to promote students' effective meaning construction.

2.5.5 Theoretical basis and analytical framework of this paper

As mentioned above, the connotation and characteristics of online learning are mainly based on the constructivist learning theory. Online learning meets the environmental conditions required for the practice of the constructivism learning theory, thus making the constructivism learning theory and online learning better combined, and becoming an important theoretical basis for scholars to study the effectiveness of online learning through the constructivism model (Jonassen D, Davidson M. Collins M C J & Haag B, 1995). Since 1990, Von Glasersfeld and other famous scholars have put forward six different tendencies of constructivism, further enriching the theory of constructivism. On this basis, researchers constructed collaborative model and cognitive information processing model to study the effectiveness of online learning (Leidner D E, Jarvenpaa S

39

L, 1995). These methods have different opinions on knowledge construction. For example, cooperativism holds that knowledge is built by learners who share and collaborate with others. The cognitive information processing model, based on the individual needs of learners, believes that the matching of curriculum design and learners' style can improve their information processing ability, thus contributing to the construction of knowledge. But in the final analysis, they all assume that knowledge is constructed.

Based on the constructivist learning theory, Piccoli et al. proposed a research model on the effectiveness of online learning under virtual learning environment (VLE) (Piccoli, 2001). Alavi and Leidner constructed a research framework for technology-mediated learning (TML) for learners to interact with external environments (Alavi&Leidner, 2001). The VLE model analyzes the effectiveness of online learning from the human dimension, which mainly refers to teachers and students, and the design dimension, which mainly refers to learners' management system, self-regulation, course design, and interaction between people. The TML research framework mainly discusses the factors affecting the effectiveness of online learning from the perspective of teaching strategies and information technology. It believes that teaching strategies and information technology factors will affect the changing process of learners' learning psychology, thus affecting the effectiveness and satisfaction of online learning. Based on the VLE model and TML research framework, Eom et al further proposed the key factors (CSF) that affect online learning, including learner motivation, information technology ability and collaborative learning situation, and constructed the corresponding research model (Hiltz S R, 1997). This model regards online learning as an open system composed of teachers, learners and management system, and points out the main factors that affect the effectiveness and satisfaction of online learning by studying the relationship among them and the interaction and function between them and the environment.

CHAPTER 3
RESEARCH METHODOLOGY

Based on the empirical study of the structural equation model, three potential variables of online learning effectiveness and satisfaction of college students were identified, and 32 observed variables were established. Based on the background of the MOOC learning platform of Chinese universities as an online learning platform, the questionnaire was designed according to the observed variables, and the questionnaire was evaluated by experts to determine the formal questionnaire. SPSS24.0 was used for statistical analysis of the data, and AMOS24.0 was used to test, modify and establish the final influencing factor model. This chapter is structured as follows:3.1 Research Design.

3.1 Research design

3.2 Population and sample

3.3 Research Instruments

3.4 Data Evaluation

3.5 Data Analysis

3.6 Questionnaire data collection and sample characteristics analysis

3.1 Research Design

The research design was conducted according to the following structure in the objective of the research; it has been moving with steps as flowing:

3.1.1 Build the theoretical framework of the research model

From the relevant theoretical research, it is found that the constructivism learning theory provides a theoretical basis for us to study the effectiveness and satisfaction of college students' online learning. Based on this theoretical basis and especially after analyzing the research model proposed by Eom et al. (Shang, Ching-Hsie, Lin, E-Soon, Juan, Chih-Yung, Chou, Ching-Yang, 2013), this paper combined with the current practice of online teaching in Chinese universities. The theoretical framework of the research model is summarized, as shown in Table 3

Table 3 Theoretical framework of the research model

Related Theories	Target expectations	Influencing Factors
Constructivism	Construct knowledge and form abstract concepts through self-directed learning, thus increasing the effectiveness and satisfaction of online learning	Knowledge construction
Collaborationism	Promote learning capacity through sharing and collaboration, thus increasing the effectiveness and satisfaction of online learning	Teacher-student interaction
Cognitive Information Processing	Promotion personalized development through cognitive information processing, thereby increasing the effectiveness and satisfaction of online learning	Information Processing

3.1.2 Build the initial model

Online learning platform is the main tool for teachers and students to interact in online teaching activities, which has a direct relationship with educators, learners and learning resources. At the same time, the functional design and other aspects of the platform will have an important impact on learning satisfaction. Educators are the transmitters of knowledge, one of the subjects of teacher-student interaction, and also an important resource builder. The teaching progress and homework difficulty in the teaching process have an impact on students' learning satisfaction. At the same time, teachers' attitudes towards online learning can also affect students' attitudes towards online learning. The interaction between learners and resources is one of the important forms of interaction in online learning. The science, interest and timing of online courses can influence the satisfaction of learners. In the aspect of learners, learners' online learning potential will positively affect online learning satisfaction. In terms of interaction, the interaction quality of online learning is influenced by teachers, students, resources and learning platforms, etc. For example, interactive content and interaction distance will have a significant positive impact on online learning satisfaction.

Based on the above three variables of knowledge construction, teacher-student interaction, and information processing, as well as the effectiveness and satisfaction of online learning, the initial model of the impact path of online learning effectiveness and satisfaction is constructed, as shown in Figure 3.2.
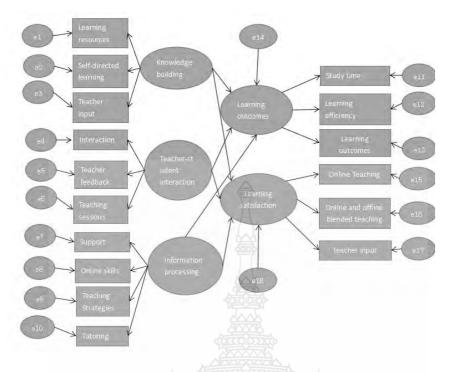
Figure 1 Theoretical model of influencing factors of college students' online learning effectiveness and satisfaction

3.1.3 9 qualified experts were contacted and their consent was sought to evaluate the online learning satisfaction questionnaire of college students by means of a questionnaire.

3.1.4 Likert Rating Scale

Data were analyzed using frequency and percentage, while questionnaires prepared for the study followed Likert's five-level rating scale. Mean(M), standard deviation(SD), and correlation were used to analyze the five scales. Respondents agreed on average from 1.00 to 1.49 and strongly disagreed on average from 4.50 to 5.00.

3.1.5 Model modification

In this study, AMOS24.0 software was used to build a structural equation model, and the maximum likelihood method was used to estimate the initial model. The results after the initial model simulation showed that the correction index MI among the three potential variables of knowledge construction, teacher-student interaction, and information processing was large, and it was necessary to add correlation paths to correct the model. At the same time, residual paths such as [e6-e9] and [e15-e16] were added, and the p-value of each path after correction was less than 0.05, which had statistical significance. The final model is shown in Figure 3.3.

43
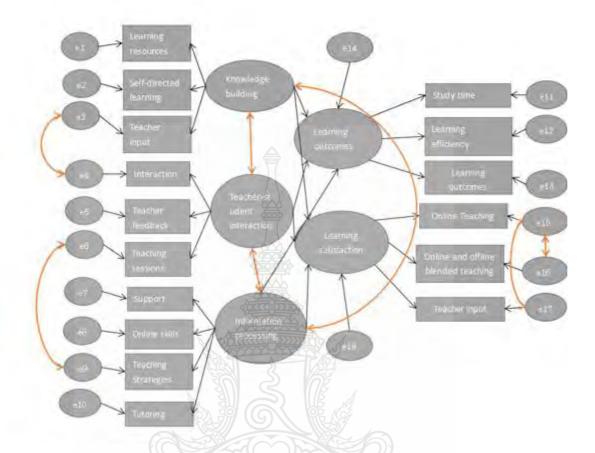
Figure 2 Modified model of the influence path of online learning effectiveness and satisfaction

3.2 Population and Sample

3.2.1 The population of this paper is 389 online college students from different schools and different majors on the MOOC online learning platform of Chinese universities. The research data are collected. The questionnaire collects questions about learning resources, independent learning, teacher input, communication and interaction, platform quality, independent learning, online skills, learning effectiveness and learning satisfaction.

3.2.2 Students were selected using purposeful random sampling. Among the surveyed students, 146 were male, accounting for 38%, and 243 were female, accounting for 62%. They all study online for more than a year.

3.3 Research Instruments

The researchers defined the following tools:

3.3.1 Construct the initial model of the influence path of online learning effectiveness and satisfaction.

3.3.2 Questionnaire on online learning effectiveness and satisfaction of college students.

3.3.3 The maximum likelihood method is used to estimate the initial model, and the revised model of the influence path of online learning effectiveness and satisfaction is finally obtained.

3.3.4 On the basis of structural equation model analysis and empirical research, the action path, the degree of relationship and the influence mechanism between each influencing factor and online learning effectiveness and satisfaction are analyzed.

3.4 Data Evaluation

3.4.1 Carefully review the online learning satisfaction questionnaire of college students, and submit the questionnaire to experts in the fields of content, educational technology, measurement, evaluation, etc., to make suggestions for improvement.

An open questionnaire was created for experts to solicit comments on the IOC(Project Objective Consistency Index).

The project Objective Consistency Index (IOC) is scored on the following criteria:

+1   means   Congruent

0   means   Questionable

-1   means   Incongruent

The items that have scored lower than 0.5 were revised. On the other hand, the items that scored higher than or equal higher than or equal to 0.5 were reversed.

3.4.2 Created a questionnaire that consisted of a rating scale with five

levels according to the Likert Scale. Each level has the following meanings:

5   means   Strongly agree

4   means   Agree

3   means   Neutral

| 2 | means | Disagree |
| 1 | means | Strongly disagree |

The criteria for translating values are as follows:

Average	Level of Opinion
4.51 – 5.00	Very good
3.51 – 4.50	Good
2.51 – 3.50	Average
1.51 – 2.50	Bad
1.00 – 1.50	Very bad

3.4.2 The independent sample T-test in SPSS24.0 was used for item analysis of the questionnaire.

3.4.3 Reliability Analysis The reliability analysis in SPSS24.0 was used to determine the reliability level by checking Cronbach's Alpha coefficient.

3.4.4 The AMOS24.0 test was used to conduct a reliability and validity test and exploratory factor analysis, and the questions were revised again to ensure the reliability and credibility of the survey tool.

3.5 Data Analysis

3.5.1 Project analysis

The results of item analysis can be used as the basis for the revision and improvement of the questionnaire. The extreme value test method and the independent sample T test in SPSS24.0 were used for item analysis of the questionnaire. First of all, the total score of each sample is calculated, which is arranged in descending order and ascending order respectively, and 27% is taken as the node to obtain the score range of high and low groups (no middle group is required). After calculation, the score range of the high group is 143~174 points, the group number of the high group is set to 1; the score range of the low group is 96~124 points, the group number of the low group is set to 2. Independent sample T test was carried out to compare the scores of the two groups. All questions passed the significance test, and all questions were retained. The questionnaire consisted of the original 32 questions.

3.5.2 Reliability analysis

Reliability analysis was performed using the reliability analysis in SPSS24.0. Cronbach'α coefficient was used to determine the reliability level, and the measurement standard was referred to Wu Minglong (2010), as shown in Table 4.

Table 1 Cronbach'α coefficient metrics

Cronbach'α Alpha coefficient range	Level or construct reliability	Scale quality
α coefficient ≥0.9	Very ideal	Very ideal
0.8≤α coefficient < 0.9	ideal	ideal
0.7≤α coefficient < 0.8	better	Settle for
0.6≤α coefficient < 0.7	Shang Jia	acceptable
0.5≤α coefficient < 0.6	acceptable	Not ideal, revised or reformulated
α coefficient < 0.5	undesirability	Very not ideal, abandon not use

In order to ensure the authenticity and effectiveness of the research results, the validity and reliability of the measurement questionnaire were tested and analyzed, specifically as follows:

Knowledge construction measurement questionnaire: A total of 13 items, including 3 dimensions: learning resources (4), independent learning (4), teacher input (5). The results of internal consistency reliability analysis showed that the Cronbach 'α series scores of the three dimensions were 0.78, 0.86 and 0.76, and the reliability coefficients of each dimension were all higher than 0.7, indicating that the reliability of the questionnaire was good. Factor analysis was used to explore the structural validity of the questionnaire. The cumulative variance contribution rate was 77.2%, and each factor fit between 0.62 and 0.89, indicating good validity.

The teacher-student interaction measurement questionnaire contains 5 items, which are composed of 2 dimensions, namely communication interaction (2 items) and teacher feedback (3 items). The results of the internal consistency reliability analysis showed that the Cronbach's α coefficients of the two dimensions were 0.73 and 0.85 respectively, and the reliability coefficients of each dimension were higher than 0.7, indicating that the reliability of the questionnaire was good. Factor analysis was used to explore the structural validity of the questionnaire. The cumulative variance contribution rate was 73.8%, and each factor fit between 0.62 and 0.89, indicating good validity.

Information Processing Measurement Questionnaire: contains 6 items and consists of 2 dimensions, namely technical support (4) and online skills (2). The results of the internal consistency reliability analysis showed that the Cronbach's α coefficients of the two dimensions were 0.91 and 0.83 respectively, and the reliability coefficients of each dimension were higher than 0.7, indicating that the reliability of the questionnaire was good. Factor analysis was used to explore the structural validity of the questionnaire. The cumulative variance contribution rate was 81.3%, and each factor fit between 0.62 and 0.91, indicating good validity.

Learning effectiveness measurement questionnaire: A total of 8 items,

including 2 dimensions, namely learning effectiveness (5) and learning satisfaction (3). The results of the internal consistency reliability analysis showed that the Cronbach's α coefficients of the two dimensions were 0.75 and 0.72 respectively, and the reliability coefficients of all dimensions were higher than 0.7, indicating that the reliability of the questionnaire was good. Factor analysis was used to explore the structural validity of the questionnaire. The cumulative variance contribution rate was 69.6%, and each factor fit between 0.64 and 0.87, indicating good validity.

The above analysis results show that the validity and reliability of each measurement questionnaire are good, which is suitable for the empirical research on the influencing factors of college students' online learning effectiveness and satisfaction.

3.5.3 Validity analysis

3.5.3.1 Content validity analysis.

The preparation of the questionnaire is based on literature research, and the latent variables of influencing factors of college students' online learning satisfaction are determined according to constructivism learning theory, educational communication theory, distance teaching interaction theory and other theoretical basis. The observational variables under each latent variable are further determined through the questionnaire of college students' online learning effectiveness and satisfaction. After the preliminary preparation of the questionnaire, the opinions of experts were sought to modify the content of the questionnaire, and predictions were made to continue to improve the questionnaire title, revise the questionnaire, and finally form a formal questionnaire. Therefore, the content reliability of the questionnaire is high.

3.5.3.2 Structural validity analysis.

Table 3.3 lists common KMO metrics.

Table 2 KNO standards

KMO statistical value	Discriminant declaration	Appropriateness of factor segmentation
Above 0.9	Ideal for factor analysis	excellent
Above 0.8	Suitable for factor analysis	good

Above 0.7	Factor analysis is still possible	moderation
Above 0.6	Factor analysis is barely possible	Normal
More than 0.5	Not suitable for factor analysis	Not good enough
Below 0.5	Very unsuitable for factor analysis	unacceptable

Firstly, SPSS24.0 was used to perform factor analysis on the data, and factor analysis was carried out on the whole questionnaire and corresponding data of each variable respectively. The KMO value of the whole questionnaire was 0.930, and the KMO value corresponding to each latent variable was above 0.8. Bartlett sphericity test showed that each latent variable and the questionnaire as a whole reached the significance level of 0.000, which indicated that the questionnaire was suitable for factor analysis.

3.6 Questionnaire data collection and sample characteristics analysis

After the questions from each dimension are analyzed and collated, the content of the formal questionnaire is determined. The research objects of the questionnaire survey are mainly college students with rich online learning experiences who have used the MOOC platform of Chinese universities. Send the questionnaire link and dimension code to the class WeChat group or forward the circle of friends to collect data. With the help of the tutor, other teachers, and students, a total of 408 questionnaires were recovered: the sample data with the same choices within 60 were excluded as invalid data, and 389 valid samples were obtained, with an effective recovery rate of 95.34%.

Students were selected using purposeful random sampling. Among the surveyed students, 146 were male, accounting for 40%, and 243 were female, accounting for 62%. They all study online for more than a year.

In the questionnaire design, the grades of learners are divided into freshman, sophomore, junior, senior, graduate first, graduate second and graduate third. The major categories are divided into literature, philosophy, etc. In the actual data analysis, it is found that the sample size is too small in some grades and some professional categories. Therefore, the grades are divided into bachelor's degree and master's degree, and the major categories are divided into science and technology, literature and history, and art. The results of sample characteristics are shown in Table 6.

Table 3 Analysis of sample characteristics

variable	form	sample size	percentage	Cumulative percentage
Gender	Male	146	37.53%	37.53%
	Female	243	62.47%	100.00%
Academic Segment	Undergraduate	296	76.09%	76.09%
	Master's Degree	93	23.91%	100.00%
Specialization	Science and Engineering	124	31.88%	31.88%
	Literature and History	232	59.64%	91.52%
	Arts and Sports	33	8.48%	100.00%

CHAPTER 4

RESEARCH RESULT

This chapter uses hierarchical linear regression analysis, single factor analysis, structural equation model analysis results, and the correlation analysis of knowledge construction, teacher-student interaction, information processing and learning effectiveness and learning satisfaction to improve college students' online learning satisfaction. The findings are as follows:

4.1 Hierarchical linear regression analysis

4.2 Single factor analysis

4.3 Structural equation model analysis results

4.1 Hierarchical Linear Regression Analysis

Before structural equation model analysis, we first adopted hierarchical linear regression analysis, taking the dimensions of basic situation, knowledge construction, teacher-student interaction, and information processing as independent variables, and set dummy variables for categorical variables (see Table 7 for specific values) to explore the influencing factors of dependent variable learning effectiveness and learning satisfaction (test level =0.05). Basic information mainly includes gender, study area, your grade, school nature, school type, and whether online teaching was used before the epidemic. In order to facilitate the research, some questions in the scale of the Online Learning Satisfaction Survey of College Students adopt the reverse scoring method. Before linear regression analysis, we convert the scores of partial reverse scoring items. The main hierarchical linear regression step is divided into four layers. The first layer: is basic situation; The second layer: is basic situation + knowledge construction three dimensions; The third layer: is basic situation + three dimensions of knowledge construction + three dimensions of teacher-student interaction; Level 4: Basic situation + three dimensions of knowledge construction + three dimensions of teacher-student interaction + four dimensions of information processing.

Table 1 Basic information Variable assignment table

Name of independent variable	Dummy variable assignment and meaning
School District（X_1）	East（X_{11}=0,0,0,0）；Middle part（X_{12}=0,1,0,0）；West（X_{13}=0,0,1,0）；Others（X_{14}=0,0,0,1）
Grade（X_2）	Specialties（X_{21}=0,0,0,0,0,0,0）；Freshman（X_{22}=0,1,0,0,0,0,0）；Sophomore（X_{23}=0,0,1,0,0,0,0）；Junior（X_{24}=0,0,0,1,0,0,0）；Senior year（X_{25}=0,0,0,0,1,0,0）；Fifth year at university（X_{26}=0,0,0,0,0,1,0）；Postgraduate（X_{27}=0,0,0,0,0,0,1）
Nature of school（X_3）	Higher Education Institutions（X_{31}=0,0,0,0）；General undergraduate institutions（X_{32}=0,1,0,0）；Research Universities（X_{33}=0,0,1,0）；Others（X_{34}=0,0,0,1）；
Type of school（X_4）	Private Colleges（X_{41}=0,0,0）；Public Universities（X_{42}=0,1,0）；Others（X_{43}=0,0,1）；

4.1.1 Results of hierarchical regression analysis with learning effectiveness as the dependent variable

The dimensions of basic situation, knowledge construction, teacher-student interaction, and information processing are taken as independent variables into layers 1 to 4, and the influence of each variable on learning effectiveness is predicted by analyzing △R2 of each layer. The results are shown in Table 8. When dimensions such as basic situation, knowledge construction, teacher-student interaction, and information processing are included in the equation, △R2 has statistical significance (△R2 =0.017, △F=6.269, P< 0.001; △R2 =0.003, △F =6.667, P< 0.001). By comparing the △R2 values of each layer, it can be seen that knowledge construction has a greater impact on learning outcomes than basic situations, teacher-student interaction, and information processing, and the ability to explain the variation of learning outcomes increases by 32.9%.

Table 2 Hierarchical regression results of learning effectiveness

Variables	Level 1 Beta	Level 2 Beta	Level 3 Beta	Level 4 Beta
Gender				
Male (reference group)				
Female	0.086**	0.035*	0.035*	0.036*

Was online teaching used prior to the outbreak				
No (reference group)				
Yes	0.042[*]			
School District				
Other (reference group)				
Middle	-0.056[**]	-0.028[*]	-0.037[*]	-0.035[*]
Grade				
Postgraduate (reference group)				
Senior	-0.089[*]			
Nature of school				
Others (reference group)				
Research Universities		-0.061[*]	-0.056[*]	-0.051[*]
Knowledge construction				
Learning resources		-0.040[*]		
Self-directed learning		0.268[**]	0.252[**]	0.264[**]
Teacher input		0.432[**]	0.242[**]	0.293[**]
Teacher-student interaction				
Teacher feedback			0.379[**]	0.370[**]
Teaching sessions			-0.090[**]	-0.095[**]
Information processing				
Financial assistance				-0.083[**]
R^2	0.015	0.344	0.443	0.445
F	6.269[**]	155.297[**]	199.484[**]	168.105[**]
$\triangle R^2$	0.017	0.329	0.098	0.003
$\triangle F$	6.269[**]	836.057[**]	294.400[**]	6.667[**]

Note: *P<0.05, **P<0.001.

Intra-group comparison of the independent variables of the final model (layer 4) showed that: compared with males, females had higher learning results (β= 0.036, p=0.001); Compared with other regions, students in central region had lower learning efficiency (β=-0.035, p=0.003). According to the quality of other subjects, the learning efficiency of students in research type college was lower (β=-0.051, p=0.037). In the knowledge construction part, the learning effectiveness increased with the increase of the mean scores of independent learning and teacher involvement (β= 0.264, p<0.001). β=0.293, p<0.001); In teacher-student interaction, the learning effectiveness increased with the increase of teaching feedback and the average score of teaching links (β=0.370, P<0.001). In the information processing part, the learning effectiveness decreased with the increase of the mean score of the tutoring dimension (β=-0.083, p<0.001).

4.1.2 Results of hierarchical regression analysis with learning satisfaction as the dependent variable

The dimensions of basic situation, knowledge construction, teacher-student interaction and information processing are entered into layers 1 to 4 successively as independent variables, and the influence of each variable on learning satisfaction is predicted by analyzing $\triangle$R2 of each layer. The results are shown in Table 9 : When the basic situation, knowledge construction, teacher-student interaction and information processing are included in the equation, $\triangle$R2 has statistical significance ($\triangle$R2 = 0.026, $\triangle$F=9.576, P<0.001). $\triangle$ R2=0.350, $\triangle$ F = 930.876, P<0.001; $\triangle$R2 =0.022, $\triangle$F=59.873, P<0.001; $\triangle$R2 =0.017, $\triangle$F =35.380, P<0.001). By comparing the $\triangle$R2 values of each layer, without analyzing the influence path, we found that knowledge construction had a greater impact on learning satisfaction than the basic situation, teacher-student interaction and information processing, and the ability to explain the variation in learning satisfaction increased by 35.0%. The results of the in-group comparison of the independent variables of the final model (layer 4) showed that the students who had used online learning before the epidemic were more satisfied with learning than those who had used online learning before the epidemic (β=0.086, p<0.001). Compared with other colleges and universities, students in higher vocational colleges and general colleges have lower satisfaction (β=-0.099, p= 0.010; β=-0.102, p=0.023); For knowledge construction, learning satisfaction increased with the increase of the average score of learning resources and independent learning (β=0.091, p<0.001), but decreased with the increase of the average score of teacher involvement (β=-0.050, p=0.008). In the student-teacher interaction, the learning satisfaction increased with the increase of the average score of communication interaction, teacher feedback and teaching process (β=0.142, p<0.001). β=0.074, p<0.001); In information processing, learning satisfaction increased with the increase of the average score of online skills and teaching strategies (β=0.120, p<0.001; β=0.058, p=0.001), and decreased with the increase of average scores of technical support and student counseling (β= -0.040, P=0.014; β=-0.127, P<0.001).

Table 3 Results of hierarchical regression of learning satisfaction

Variables	Level 1 Beta	Level 2 Beta	Level 3 Beta	Level 4 Beta
Gender				
Male (reference group)				
Female	0.033*			
Was online teaching used prior to the outbreak				
No (reference group)				
Yes	0.140**	0.088**	0.086**	0.086**
School District				
Other (reference group)				
West	-0.050			

Grade				
Postgraduate students (reference group)				
Sophomore		-0.108	-0.105	
Junior	-0.108	-0.096	-0.099	
Nature of school				
Other (reference group)				
Higher Education Institutions	-0.149	-0.107	-0.110	-0.099
General undergraduate institutions	-0.145	-0.118	-0.114	-0.102
Type of school				
Other (reference group)				
Private institutions			0.245*	
Public institutions			0.252*	
Knowledge construction				
Learning resources		0.154**	0.090**	0.091**
Self-directed learning		0.532**	0.455**	0.435**
Teacher input		-0.125	-0.128	-0.050
Teacher-student interaction				
Communication and interaction			0.179**	0.142**
Teacher feedback			0.079**	0.074**
Teaching sessions				-0.069
Information processing				
Technical Support				-0.040
Online skills				0.120**
Teaching Strategies				0.058*
Financial assistance				-0.127
R^2	0.026	0.376	0.398	0.412
F	9.576**	176.571**	164.387**	146.670**
$\triangle R^2$	0.026	0.350	0.022	0.017
$\triangle F$	9.576**	930.876**	59.873**	35.380**

Note: *$P<0.05$, **$P<0.001$.

4.2 Single Factor Analysis

4.2.1 Single factor analysis of learning effectiveness

Single-factor results showed that there were statistically significant differences in learning effectiveness among students of different genders, school regions, whether they had used online teaching before the epidemic, different grades, and school types ($p<0.05$), while there were no statistically significant differences in learning

effectiveness among students with different school nature (p>0.05), as shown in Table10.

Table 4Univariate analysis of learning outcomes (x±S)

Variables	Classification	x±S	*t/F value*	*p-value*
Gender	Male	2.80±0.74	-6.004	<0. 001*
	Female	2.92±0.65		
School District	East	2.90±0.72	3.822	0.010*
	Middle	2.83±0.69		
	West	2.85±0.70		
	Others	3.02±0.83		
Was online teaching used prior to the outbreak	No	2.84±0.68	-2.655	0. 008*
	Yes	2.89±0.71		
Grade	Specialties	2.87±0.56	3.531	0. 003*
	Freshman	2.87±0.67		
	Sophomore	2.88±0.69		
	Junior	2.87±0.72		
	Senior	2.70±0.82		
	Postgraduate	2.98±0.68		
Nature of school	Higher Education Institutions	2.84±0.62	0.405	0.749
	General undergraduate institutions	2.87±0.70		
	Research Universities	2.82±0.74		
	Others	2.95±0.64		
Type of school	Public Universities	2.88±0.69	4.107	0. 017*
	Private Institutions	2.81±0.71		
	Others	3.02±0.83		

4.2.2 Single factor analysis of learning satisfaction

According to the results of single factor analysis, there were statistically significant differences in learning satisfaction among students in different school regions, whether they had used online teaching before the epidemic and different grades (p<0.05). Students with different gender, school nature and school categories had no statistical significance in learning satisfaction (p>0.05), as shown in Table 11.

Table 5 Univariate analysis of learning satisfaction (x±S)

Variables	Classification	x±S	t/F value	p-value
Gender	Male	3.19±0.80	-1.850	0. 064
	Female	3.23±0.73		
School District	East	3.24±0.77	2.894	0. 034*
	Middle	3.22±0.75		
	Western	3.15±0.76		
	Others	3.29±0.08		
Was online teaching used	Negative	3.13±0.77	-9.43	<0. 001*
prior to the outbreak				
	Positive	3.33±0.73		
Grade	Specialties	3.19±0.65	2.461	0. 031*
	Freshman	3.25±0.72		
	Sophomore	3.18±0.78		
	Junior	3.19±0.78		
	Senior year	3.24 ±0.84		
	Postgraduate	3.42±0.57		
Nature of school	High Ranking	3.13±0.77	2.196	0.086
	General Undergraduate Institution	3.22±0.76		
	Research University	3.32±0.86		
	Others	3.41±0.66		
Type of school	Public Universities	3.22±0.76	1.078	0.340
	Private Colleges	3.18±0.77		
	Others	3.29±0.80		

4.2.3 Correlation analysis

In terms of knowledge construction, the three dimensions of learning

57

resources, self-directed learning and teacher involvement are positively correlated with learning effectiveness and learning satisfaction, among which the correlation between teacher involvement and learning effectiveness is the strongest, and the correlation between self-directed learning and learning satisfaction is the strongest. In terms of teacher-student interaction, communication interaction, teacher feedback and teaching links are positively correlated with learning effectiveness and learning satisfaction, in which teacher feedback and learning effectiveness have the strongest correlation, and communication interaction and learning satisfaction have the strongest correlation. In terms of information processing, the four dimensions of technical support, online skills, teaching strategies and tutoring are positively correlated with learning effectiveness and learning satisfaction, among which the correlation between teaching strategies and learning effectiveness is the strongest, and the correlation between online skills and learning satisfaction is the strongest. For details, see Table 12

Table 6 Correlation analysis of knowledge construction, cooperative learning, information processing, learning effectiveness and learning satisfaction

Category	Dimensional	Learning effectiveness	Learning satisfaction
Knowledge construction	Learning resources	0.328**	0.467**
	Self-directed learning	0.441**	0.586**
	Teacher input	0.541**	0.187**
Teacher-student interaction	Interaction	0.199**	0.487**
	Teacher feedback	0.575**	0.249**
	Teaching sessions	0.139**	0.365**
Information processing	Technical Support	0.341**	0.137**
	Online skills	0.204**	0.435**
	Teaching Strategies	0.352**	0.345**
	Financial assistance	0.349**	0.140**

4.3 Structural equation model analysis results

4.3.1 Model fitting

Correlation paths need to be added to modify the model, and residual paths such as [e6-e9] and [e15-e16] need to be added. After modification, the p-value of each path is less than 0.05, which has statistical significance. Due to the large sample size of the study, the CMIN/DF index was too large, but the fitting results combined with other fit indexes were better, as shown in Table 13.

Table 7 Fitting results of the structural equation model

Fit index	Fit Value	Whether the fit criteria are met
Indicators of absolute fit:		
AGFI	0.910	Confirm
GFI	0.948	Confirm
RMSEA	0.044	Confirm
Value-added fitness indicators:		
CFI	0.950	Confirm
NFI	0.946	Confirm
Pared fit indicators:		
PNFI	0.515	confirm
PGFI	0.544	confirm
CMIN/DF	7.97	On the large side

4.3.2. Fitting the path analysis results of the model

It can be seen from the model that knowledge construction has a positive effect on learning effectiveness and learning satisfaction, and the standardized path coefficients are 0.319 and 0.174, respectively (p<0.01). Teacher-student interaction had a positive effect on learning effectiveness and learning satisfaction, and the standardized path coefficients were 0.351 and 0.281, respectively (p<0.05). See Table 14 for details.

Table 8 Fit the effect relationship between the factors in the model

Variables			Standard path Estimated value	C.R.	p
Learning satisfaction	<---	Knowledge construction	.174	5.149	.002
Learning satisfaction	<---	Information processing	.249	6.956	.050
Learning satisfaction	<---	Teacher-student interaction	.281	8.208	<0.001
Learning effectiveness	<---	Knowledge construction	.319	9.317	<0.001
Learning effectiveness	<---	Student-teacher interaction	.351	10.903	<0.001
Learning effectiveness	<---	Information processing	.193	5.612	<0.001

Teacher input	<---	Knowledge construction	.762		
Self-directed learning	<---	Knowledge construction	.530	24.886	<0.001
Learning resources	<---	Knowledge construction	.685	28.536	<0.001
Teacher feedback	<---	Teacher-student interaction	.795	43.118	<0.001
Teaching Strategies	<---	Information processing	.724	39.291	<0.001
Online skills	<---	Information processing	.695	35.675	<0.001
Technical Support	<---	Information processing	.785		
Online Teaching	<---	Learning satisfaction	.389		
Financial assistance	<---	Information processing	.790	40.225	<0.001
Interaction	<---	Student-teacher interaction	.832		
Teaching sessions	<---	Student-teacher interaction	.529	26.9	<0.001
Off-line teaching	<---	Learning satisfaction	.813	19.733	<0.001
Online and offline blended teaching	<---	Learning satisfaction	.403	18.317	<0.001
Study time	<---	Learning effectiveness	.816		
Learning outcomes	<---	Learning effectiveness	.608	28.304	<0.001
Learning efficiency	<---	Learning effectiveness	.786	35.202	<0.001

4.3.3 Effect relationship and hypothesis testing results

By analyzing the interaction between the latent variables of the modified structural equation model, it can be seen that knowledge construction only has a direct positive impact on learning effectiveness, and the path series is 0.319 (p< 0.01). The teacher-student interaction had a direct positive effect on the learning effect, and the path coefficient was 0.351 (p< 0.01). Knowledge construction had a direct positive effect on learning satisfaction, and the path coefficient was 0.174 (p< 0.01). Information processing had a direct positive effect on learning satisfaction, and the path coefficient was 0.249 (p< 0.05). According to the standardization influence effect analysis, the total effect on

learning effectiveness is as follows: teacher-student interaction (0.351) > knowledge construction (0.319) > information processing (0.193), and the total effect on learning satisfaction is as follows: Teacher-student interaction (0.281) > Information processing (0.249) > Knowledge construction (0.174), as shown in Table 15.

Table 9 Coefficients and validation assumptions for each impact pathway

No.	Pathways of Influence	Standardize direct effect values	Standardize indirect effect sizes	Standardize the total effect size	p	Support Assumptions
1	Knowledge construction → learning outcomes	0.319	\	0.319	< 0.01	1
2	Teacher-student interaction → learning outcomes	0.351	\	0.351	< 0.01	1
3	Information processing → learning effectiveness	0.193	\	0.193	< 0.01	1
4	Knowledge construction → learning satisfaction	0.174	\	0.174	0.002	1
5	Teacher-student interaction → learning satisfaction	0.281	\	0.281	< 0.01	1
6	Information processing	0.249	\	0.249	0.05	1

→ Learning satisfactio n				

CHAPTER 5
DISCUSSION AND RECOMMENDATION

In studying the effectiveness and satisfaction of college students' online learning, there are three main objectives: 1) To determine the factors that influence the effectiveness and satisfaction of college students' online learning. 2) With the help of relevant theoretical basis, build a model of factors affecting college students' online learning effectiveness and satisfaction. On the basis of structural equation model analysis and empirical research, the paper analyzes the interaction path, the degree of relationship and the influence mechanism between each influencing factor and e-learning effectiveness and satisfaction. 3) According to the problems found in the research, strategies to improve the effectiveness and satisfaction of college students' online learning are proposed from the aspects of knowledge construction, teacher role, and information processing. It provides a practical reference value for the sustainable development of online education in China. The conclusions, discussion, and recommendations of the study are as follows:

5.1 Research Conclusions

5.2 Discussion and Enlightenment

5.3 Suggestions

5.1 Research Conclusions

Based on the data from the Questionnaire on College Students' Online Learning Satisfaction, we studied the effects of knowledge construction, teacher-student interaction and information processing on college students' online learning effectiveness and satisfaction and their paths through the structural equation model, and reached the following conclusions:

5.1.1 Correlation between knowledge construction, teacher-student interaction and information processing and e-learning outcomes.

Knowledge construction, teacher-student interaction and information processing have a direct positive impact on learning outcomes, that is, intermediate variables have no effect on the transmission path. This further shows that students' online learning effectiveness is directly influenced by knowledge construction, teacher-student interaction and information processing factors, and has a positive effect. Moreover, it can

be known from the standardization influence effect analysis that the total effects affecting students' online learning effectiveness are as follows: teacher-student interaction > knowledge construction > information processing. It shows that the importance of teacher-student interaction for students' online learning is more prominent under the current background of online teaching. In terms of learning outcomes, information processing has the least impact on teacher-student interaction and knowledge construction.

5.1.2 The correlation between knowledge construction, teacher-student interaction and information processing and online learning satisfaction.

Knowledge construction, teacher-student interaction and information processing have direct positive effects on learning satisfaction, which also indicates that intermediate variables have no effect on the transmission path. It also shows that students' online learning satisfaction is directly affected by knowledge construction, teacher-student interaction and information processing, and has a positive effect. In addition, through the standardization influence effect analysis, we found that the total effect of students' online learning satisfaction is: teacher-student interaction > information management > knowledge construction. This shows that in the current context of online teaching, teacher-student interaction has the greatest impact on students' learning satisfaction, while knowledge construction has the least impact on teacher-student interaction and information processing.

5.1.3 Correlation between observed variables corresponding to each potential variable and learning effectiveness and satisfaction.

In terms of knowledge construction, the three dimensions of learning resources, self-directed learning and teacher involvement are positively correlated with learning effectiveness and learning satisfaction, among which the correlation between teacher involvement and learning effectiveness is the strongest, and the correlation between self-directed learning and learning satisfaction is the strongest. In terms of teacher-student interaction, communication interaction, teacher feedback and teaching links are positively correlated with learning effectiveness and learning satisfaction, in which teacher feedback has the strongest correlation with learning effectiveness, communication interaction has the strongest correlation with learning satisfaction. In terms of information processing, the four dimensions of technical support, online skills, teaching strategies and tutoring are positively correlated with learning effectiveness and learning satisfaction. The correlation between teaching strategies and learning effectiveness is the strongest, and the correlation between online skills and learning satisfaction is the strongest.

5.1.4 Influence of observed variables corresponding to each potential variable on learning effectiveness.

From the perspective of knowledge construction, learning effectiveness increases with the increase of the average scores of self-learning and teacher involvement.

From the perspective of teacher-student interaction, learning effectiveness increases with the increase of the average score of teaching feedback and teaching links. From the point of view of information processing, the learning effectiveness decreases with the increase of the average score of the observed variable. According to the question items corresponding to each observed variable, it accords with the actual situation. For example, "teachers can give timely feedback on homework" in teacher feedback can positively affect students' online learning effectiveness, while "no course assistants or insufficient number" in financial assistance has a negative impact on students' online learning effectiveness.

5.1.5 Influence of observed variables corresponding to each potential variable on learning satisfaction.

From the perspective of knowledge construction, learning satisfaction increases with the increase of the average scores of learning resources, autonomous learning and teaching links. From the perspective of teacher-student interaction, learning satisfaction increases with the increase of the average score of interaction, teacher feedback and teaching process. From the perspective of information processing, learning satisfaction increased with the increase of the average score of online skills and teaching strategies, but decreased with the increase of the average score of technical support and tutoring. Similarly, the question items corresponding to each observed variable are more consistent with the actual situation. For example, in the teaching process, "teachers frequently conduct after-school question-answering tutoring" can positively affect students' satisfaction with online learning, while in the technical support, "imperfect teaching platform functions and poor stability" can negatively affect students' satisfaction with online learning. In the study, we also found that female students are more effective and satisfied with online learning than male students, graduate students are more effective and satisfied with online learning than undergraduate students, and students in the eastern region are more effective and satisfied with online learning than students in the other two regions. In addition, we also found that although the three dimensions of "knowledge construction", "teacher-student interaction" and "information processing" all have simultaneous effects on learning effectiveness and learning satisfaction, the degree of effect is different. For example, among undergraduates, sophomore students are higher than other students in terms of learning effectiveness; In terms of study satisfaction, freshmen students are higher than other grade students. In fact, Conclusion 1 and Conclusion 2 have already told us that the total effects affecting students' online learning effectiveness are in the order of teacher-student interaction > knowledge construction > information processing, while the total effects affecting students' online learning satisfaction are in the order of teacher-student interaction > information processing > knowledge construction. Therefore, it can be shown that in the case of little difference in teacher-student interaction, sophomore students pay more attention to the cultivation of knowledge construction ability in online learning than other grade students, while freshman students pay more attention to information processing. The above conclusions well answer the three research questions raised earlier in this paper, and fully verify our research hypothesis that knowledge construction, teacher-student interaction, and information processing have a positive impact on college students' learning effectiveness and

satisfaction, which is in line with the constructivism learning theory. In addition, this study did not use a ready-made scale in the observation process, but constructed a questionnaire for each observed variable by analyzing relevant questions in the Questionnaire on Online Learning Satisfaction of College Students. As mentioned above, we have tested the validity and reliability of the questionnaire before the empirical test, and the results are good. According to the above explanation of the research conclusions, it is again confirmed that the scale composed of these measurement questions is valid and credible.

5.2 Discussion and Enlightenment

Based on the previous analysis and discussion, this study draws the following implications:

5.2.1

As with offline learning, teachers and support staff continue to play an important role in improving student effectiveness and satisfaction in online learning. From the structural equation model analysis results, whether it is knowledge construction, teacher-student interaction or information processing variables, it fully shows the important role of teachers and teaching assistants. For example, in terms of teachers' teaching ability, teachers' teaching strategies, teaching methods and mastery of educational technology are important factors that affect students' online learning effectiveness and satisfaction. In terms of the participation of teachers and teaching assistants, teachers' support and help to students' learning materials, good attitude and energy input, frequency and quality of communication and interaction, feedback and follow-up of homework, control and management of students' progress, and the allocation of teaching assistants are all important factors affecting students' online learning effectiveness and satisfaction. Therefore, giving full play to the role of teachers and teaching assistants in students' online learning is an important aspect that organizers need to consider. However, how to play the role needs to be different from the offline situation and combined with the characteristics of students' online learning. Many scholars have a basic consensus on the role of teachers in students' online learning, and generally believe that teachers are not "saints on the stage", and should be good guides and supporters of students' learning based on the concept of "student-centered".

5.2.2

Compared with offline classes, the effectiveness and satisfaction of online learning are more reflected in students' information processing and knowledge construction abilities. As mentioned above, the characteristics of online learning are very consistent with the constructivist learning theory, so how to strengthen students' information processing ability and knowledge construction ability is the key to improve students' online learning effectiveness and satisfaction. For educators, on the one hand, they should focus on cultivating students' information technology ability and improving their information

processing quality in the learning process, so as to help them to recognize, select and reconstruct information, so as to complete the construction of new information and knowledge. On the other hand, it is necessary to strengthen the cultivation of students' independent learning and self-regulation ability, cultivate their good online learning habits, encourage them to arrange and design learning plans suitable for themselves, so as to help them identify and solve problems at their own pace and process, so as to promote the construction of learning knowledge and the improvement of learning ability. Therefore, in the normal online learning organization, educators should abandon the habit of "teachers actively teach and students passively receive" in the traditional offline classroom, create a good and relaxed environment, and adopt effective strategies to encourage and guide students to carry out high-quality online learning, and gradually cultivate their cognitive information processing and knowledge construction abilities. To improve online learning effectiveness and satisfaction. In addition, from the previous analysis, we can see that the improvement of learning effectiveness is more about supporting the cultivation of students' knowledge construction ability than learning satisfaction. Compared with the learning effect, the improvement of learning satisfaction lies more in the support of the cultivation of students' information processing ability. Therefore, in the online classroom, educators should have their own emphasis on the grasp of the two according to different purposes.

5.2.3

Compared with traditional learning, the improvement of students' effectiveness and satisfaction in online learning emphasizes more on the support of course resources and the quality of course design. We know that teachers occupy a central position in traditional offline classroom learning, and students' learning arrangements generally need to be completed by teachers. For example, the learning process, the homework plan and even the so-called independent learning after class are actually carried out under the guidance of the teacher. For students, just follow the learning logic and content designed by the teacher to learn. It is not that online learning does not require teachers' instructional design, but it is precisely because online learning emphasizes students' fully autonomous learning, so teachers' instructional design requirements are higher. Online learning "is not because of the powerful course resource platform system and various technical tools can be naturally successful, teachers must do a good job in the new environment of teaching design". This kind of teaching design is different from the offline classroom teaching which focuses on teaching methods, and it emphasizes more on the structured arrangement of course resources and the design of course content. Because the teaching design of online learning should meet the requirements of students' online independent learning and self-regulation, it should be more prominent to guide the cultivation of students' self-inquiry ability in the learning process. Therefore, a high-quality online teaching design should pay attention to the planning and design of course resource content, and should take "adapting to students' learning exploration" as the main goal, which is really conducive to the improvement of students' online learning effectiveness and satisfaction. In fact, when course resources are organized into logical and easy to understand and accept learning content, students will have a stronger desire to learn and a sense of inquiry, which makes

them more successful in deep online learning.

5.2.4.

Based on the current reality, the soft and hard conditions of education informatization and the drive of external environment are still important factors to promote students' online learning. According to the survey data of "College Students' Online Learning Satisfaction Survey", "National online learning" has also exposed the defects in the construction of information software and hardware in many colleges and universities in China, and it can also be seen that the differences in the external environment between eastern, central and western regions and different types of schools. Such defects and differences will certainly affect students' enthusiasm for online learning, and have an even greater impact on learning effectiveness and satisfaction. In the study, we also found that technical support indicators such as "network speed and stability", "teaching platform function and stability", "online technical service support" and "learning space environment and terminal equipment" directly affect students' effectiveness and satisfaction, while some external factors such as "school policy support" also have a greater impact on students' online learning. With the rapid development of modern science and technology and the Internet, technical literacy will inevitably occupy an increasingly important position in future learning. In fact, "digital technology literacy has become a necessary ability in the Internet era, only in the information teaching environment, it is possible to cultivate such abilities as digital technology literacy." Therefore, strengthening the construction and support of students' online learning environment will be the work of education departments and schools in a certain period of time.

5.3 Suggestions

5.3.1 Research results

1) Innovation of research perspective. This paper combines constructivist learning theory, educational communication theory and distance learning interaction theory to determine the influence factors of college students' online learning satisfaction.

2) Innovation of model construction. Based on the empirical study of structural equation model, three potential variables of online learning effectiveness and satisfaction of college students are identified, and the important mediating role of interaction is found, which provides a new direction for future research. Secondly, the paper analyzes the effect path, the degree of relationship and the mechanism of influence between each influencing factor and e-learning effectiveness and satisfaction.

5.3.2 Research Prospects

On the basis of the two models of influencing factors of college students' online learning satisfaction constructed in this paper, further research can be carried out

from the following aspects.

1) Expand the number of samples, broaden the source channels of samples, conduct a validation test on the model of influencing factors of college students' online learning satisfaction constructed in this paper, explore the applicability of the model across samples and contexts, test the universality of the model, and further improve the quality and value of the model. In the data analysis, the online learning satisfaction can be studied by regression analysis and other analysis methods, and the regression equation can be obtained.

2) In the follow-up research, the satisfaction level of learners in the course teaching of different disciplines can be explored in combination with specific course cases. In the actual course practice, it puts forward more focused strategies to improve online learning satisfaction.

3) The important mediating role of interaction was found in the study. Interaction, as the most influential intermediary variable, has a direct and indirect impact on online learning satisfaction. In the follow-up research, the specific impact relationship between interaction and online learning satisfaction can be explored from the aspects of students' interaction motivation and interaction behavior.

5.3.3 Suggestions

Strategies to improve college students' online learning satisfaction. This paper puts forward some countermeasures to improve college students' online learning satisfaction from five aspects: educators, learners, learning resources, learning platforms and interaction.

First, at the level of educators, improve the professional quality of teachers and establish the concept of lifelong learning. Educators should improve the cognitive level of information technology, maintain a positive attitude, and improve the ability to use media technology to assist education and teaching.

Second, at the learner level, cultivate the core literacy of information technology and face the intelligent challenges of the digital age. Learners should strengthen self-management ability, clarify learning motivation, cultivate independent learning ability, pay attention to cultivating the core quality of information literacy, and improve the ability to use media to assist learning.

Third, at the interaction level, strengthen the interaction depth and promote deep learning. Teachers can design mixed teaching activities to promote the communication between teachers and students. Learners should also gradually form a learning community through discussion and cooperation: the platform should effectively improve the load and reliability, and promote personalized learning through technology; In

terms of resources, we should also improve their science and richness.

Fourth, in terms of platform, we should pay attention to technological innovation and achieve accurate education. In the design of online learning platform, attention should be paid to optimizing various functional modules to meet learning needs; in the development, attention should be paid to strengthening technological innovation and improving security mechanism.

Fifth, in terms of resources, to ensure scientific and effective, strengthen the use and integration. Resource construction should be based on science to make resources more abundant and personalized, and relevant departments should also actively integrate high-quality education resources to maximize the value of resources.

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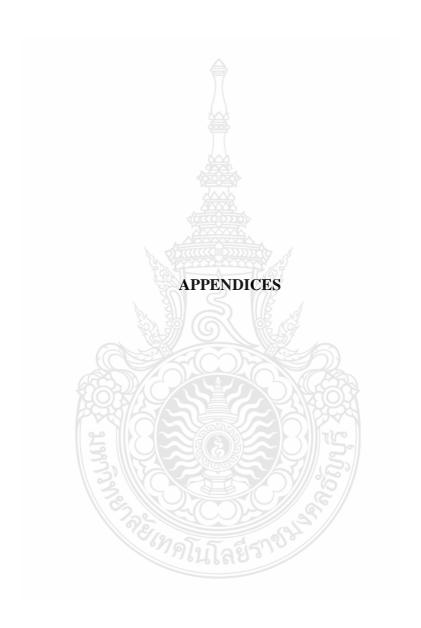
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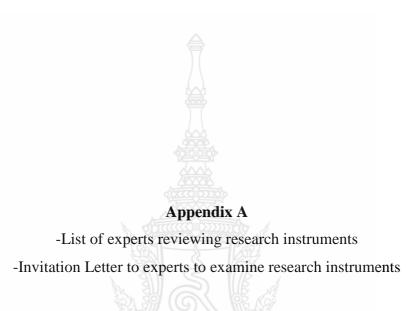
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APPENDICES

81

Appendix A

-List of experts reviewing research instruments

-Invitation Letter to experts to examine research instruments

List of experts who reviewed research instruments

Content Specialists

1. Prof.Shunan Zheng

   Tsinghua University

2. Prof.Jing Li

   Beijing Jiaotong University

3. Asst.Prof.Xin Wang

   Beihang University

Media Specialists

1. Asst.Prof.Xinyuan Zhang

   Beijing City University

2. Prof.Pingfang Yuan

   Communication University of China

3. Prof.Zhiming Wang

   University of Science and Technology Beijing

Assessment Specialists

1. Asst.Prof.Yanqiong Yang

   China Modern Education Research Center

2. Prof.Wei Wang

   Beijing Normal University

3. Prof.Yongmei Jia

   China Association of Private Education

MHESI 0962.45/2023

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27 July, 2023

Dear Dr.Shunan Zheng
Tsinghua University

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

MHESI 0962.46/2023

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Klong Luang, Pathum Thani 12110 Thailand
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27 July, 2023

Dear Dr.Jing Li

Beijing Jiaotong University

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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27 July, 2023

Dear Asst.Prof.Dr.Xin Wang

Beihang University

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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27 July, 2023

Dear Asst.Prof.Dr.Xinyuan Zhang
Beijing City University

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

87

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27 July, 2023

Dear Dr.Pingfang Yuan
    Communication University of China

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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Klong Luang, Pathum Thani 12110 Thailand
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27 July, 2023

Dear Dr.Zhiming Wang
University of Science and Technology Beijing

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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Office of the Dean, Faculty of Technical Education
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Klong Luang, Pathum Thani 12110 Thailand
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27 July, 2023

Dear Asst.Prof.Dr.Yanqiong Yang

China Modern Education Research Center

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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Klong Luang, Pathum Thani 12110 Thailand
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27 July, 2023

Dear Dr.Wei Wang
Beijing Normal University

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

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Tel:+66-2-549-4710 Fax:+66-2-577-5049

27 July, 2023

Dear Dr.Yongmei Jia
China Association of Private Education

Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Ms.Yanping Dai, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Research on influencing factors of college students' online learning effectiveness and satisfaction based on the structural equation model". under the supervision of Assistant Professor Dr. Tiamyod Pasawano. In this regard, I would like to request your valuable time to evaluate the research instruments as I strongly believe that your expertise will be of great value in improving the research instruments.

If you have any questions or need further information, please feel free to contact Ms.Yanping Dai, on the e-mail: yanping_d@mail.rmutt.ac.th

Yours sincerely,

(Assistant Professor Arnon Niyomphol)
Dean of Faculty of Technical Education

93

Appendix B
College students online learning satisfaction questionnaire

Appendix B
College students online learning satisfaction questionnaire

Dear students,

Hello! In order to further improve the quality of online education and create a better online learning experience, we conducted this questionnaire survey to understand the current status and influencing factors of college students' online learning effectiveness and satisfaction. Your answers and opinions are of great significance to the construction of online learning resources and the optimization of the platform. Please truly answer the questions in the questionnaire and hit √ before the option that most conforms to your actual situation.

The questionnaire consisted of a five-level rating scale based on the Likert scale. Each level has the following meanings:

5	means	Strongly agree
4	means	Agree
3	means	Neutral
2	means	Disagree
1	means	Strongly disagree

The criteria for translating values as follows:

Average	Level of opinion
4.51 – 5.00	Very good
3.51 – 4.50	Good
2.51 – 3.50	Average
1.51 – 2.50	Bad
1.00 – 1.50	Very bad

Description		Likert Scales				
		5	**4**	**3**	**2**	**1**
1. Learning Resources						
1.1	The practicability of learning content, the help to study and life	□	□	□	□	□
1.2	How about learning resources? Whether	□	□	□	□	□
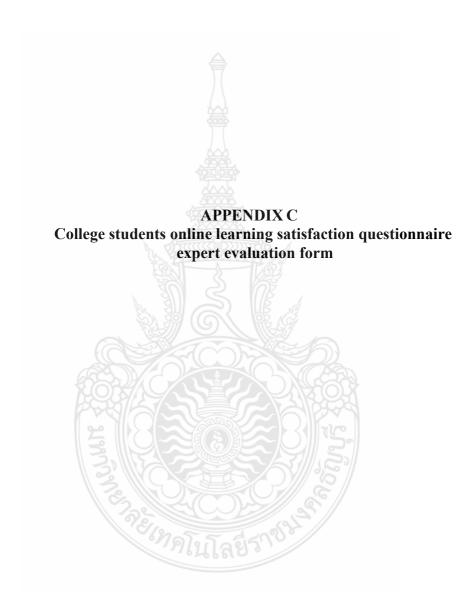
	it can meet the learning needs					
1.3	Learn the rationality of content arrangement	□	□	□	□	□
1.4	Learning resource update speed	□	□	□	□	□
2. Independent learning						
2.1	How much you like online learning	□	□	□	□	□
2.2	Whether it is conducive to the cultivation of independent learning	□	□	□	□	□
2.3	Self-management and self-discipline	□	□	□	□	□
2.4	How is your online learning progress	□	□	□	□	□
3. Teacher engagement						
3.1	How do teachers maintain the order of online classroom teaching	□	□	□	□	□
3.2	How can teachers control the progress of online teaching	□	□	□	□	□
3.3	Whether the teacher's classroom activity design is novel or not	□	□	□	□	□
3.4	Whether the teacher can influence you to have a positive attitude towards online learning	□	□	□	□	□
3.5	What is the teacher's attitude and commitment to teaching					
4. Communication and interaction						

4.1	Can you get timely answers from teachers when you ask questions on the platform	☐	☐	☐	☐	☐
4.2	Whether you can answer the teacher's questions positively	☐	☐	☐	☐	☐
5.Teacher feedback						
5.1	Whether the teacher can give timely feedback on the homework	☐	☐	☐	☐	☐
5.2	Whether teachers can keep abreast of students' knowledge	☐	☐	☐	☐	☐
5.3	Whether the teacher understands the online learning status of the students	☐	☐	☐	☐	☐
6. Technical support						
6.1	How fast and stable is the network	☐	☐	☐	☐	☐
62	Whether the functions of the platform are rich	☐	☐	☐	☐	☐
6.3	Whether the platform is convenient and fast to operate	☐	☐	☐	☐	☐
6.4	Whether the platform can provide better learning support services	☐	☐	☐	☐	☐
7. Online skills						
7.1	Good command of the platform	☐	☐	☐	☐	☐
7.2	Whether you can use various online learning tools well	☐	☐	☐	☐	☐

8. Learning time						
8.1	Free to study without time constraints	☐	☐	☐	☐	☐
8.2	The learning efficiency of online learning					
9. Learning effect						
9.1	On-line communication effect	☐	☐	☐	☐	☐
9.2	There is no change compared with traditional offline learning	☐	☐	☐	☐	☐
9.3	Whether it can achieve the expected learning effect	☐	☐	☐	☐	☐
10. Learning satisfaction						
10.1	Would you still choose to study online	☐	☐	☐	☐	☐
10.2	Whether you can accept the teaching mode of online learning	☐	☐	☐	☐	☐
10.3	Do you like "online + offline" blended learning					

Other suggestions

....

....

....

....

     Thank you for cooperation

Mrs.Yanping Dai
Signature.......................
....

Ed.D student RMUTT   (Name of
Evaluator)

                                                   Content Expert

APPENDIX C
College students online learning satisfaction questionnaire
expert evaluation form

APPENDIX C
College students online learning satisfaction questionnaire
expert evaluation form
To evaluate the factors influencing the effectiveness and satisfaction of
college students' online learning based on the Structural Equation Model

Direction: Please evaluate the instrument by putting a check mark (√) in the box and write
suggestions that might help for the improvement of the research.
Use the following symbols in validating the contents.

+1 Means it's adequate and consistent with what is intended for the study.

0 Means not sure if it's adequate or consistent with what is intended for the stydy.

-1 Means inadequate and inconsistent with what is intended for the study.

Comments and Evaluation of Content experts

No.	Assessment list	Expert's Evaluation			Suggestion
		+1	0	-1	
1	Overall evaluation of questionnaire design				
2	Questionnaire content design evaluation				
3	Evaluation of questionnaire content structure				
4	Questionnaire measurement index design evaluation				
5	Whether the total number of tests per content is sufficient				
6	Whether the content is clear and understandable				
7	Whether the language expression is appropriate				
8	Whether the questions set in the questionnaire are reasonable				

Other suggestions

....

Thank you for cooperation

Mrs.Yanping Dai   Signature.......................
....

Ph.D. student RMUTT   (Name of Evaluator)

Content expert

Biography

Name-Surname   Mrs. Yanping Dai

Date of Birth   June 17, 1978

Address   Faculty of Technical Education Rajamangala University

                       of Technology Thanyaburi, Pathumthani, 12110

Education   Bachelor of Education,
                       Shanxi University
                       Master of Software Engineering
                       Beijing JiaoTong University

Work Experience

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