BLENDED LEARNING ENGAGEMENT EVALUATION SYSTEM FOR UNIVERSITY IN CHINA

YU LIU

A DISSERTATION SUMMITED IN PARTIAL FULFILLMENT OF
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PROGRAM IN VOCATIONAL EDUCATION
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RAJAMANGALA UNIVERSITY OF TECHNOLOGY THANYABURI
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Dissertation Title Blended Learning Engagement Evaluation System for University in China
Name-Surname Mrs. Yu Liu
Program Vocational Education
Dissertation Advisor Assistant Professor Thosporn Sangsawang, Ph.D.
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ABSTRACT

This study aimed to: 1) synthesize various assessment indicators of blended learning engagement and 2) create an evaluation framework for the engagement of university students in blended teaching environments.

The research samples consisted of three groups: 1) 17 education experts from different universities, all holding doctoral degrees or above, selected through purposive sampling, 2) 100 teachers with blended teaching experiences from five universities in Sichuan province, China and 3) 226 teachers with blended teaching experiences at Sichuan University of Science & Engineering, selected through stratified sampling. Data collection tools included semi-structured interviews and seven questionnaires. Statistical data utilized for data analysis encompassed frequencies, percentages, means, standard deviations, and the Delphi technique. An assessment framework was developed for measuring engagement in blended learning and it was applied to evaluate the engagement of undergraduate students at Sichuan University of Science & Engineering.

The results indicated that undergraduate students at the university demonstrated good levels of engagement in blended learning. The analysis of the indicators also identified areas for potential improvement. These findings should be valuable to educators and institutions seeking to enhance student engagement in blended learning environments and thereby improve the overall learning experiences.

Keywords: blended learning engagement, Delphi technique, AHP, evaluation system

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Yu Liu

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CHAPTER 1
INTRODUCTION

1.1 Background and Statement of the Problem

1.1.1 Learning engagement has become a hot topic in teaching research in various countries

In the second half of the 20th century, international competition shifted towards competition in the knowledge economy. Countries around the world recognized the need to adapt and prioritize educational reform in order to stay competitive in this new global landscape. They realized that the key to success in the knowledge economy lied not only in producing a well-educated workforce, but also in providing students with the necessary skills to thrive in a rapidly evolving and technologically advanced society.(Hvidt, 2014).Many studies on online teaching and learning have focused on learning engagement. Online learning has gained significant momentum in recent years, providing a flexible and accessible educational platform.In recent years, there has been a notable shift in the research content of positive psychology towards learning engagement. This shift is led by American scholars who are exploring the impact of positive psychology on students' learning experiences. They aim to understand the factors that promote student engagement and enhance their overall well-being in educational settings (Wang & Degol, 2014).This research trend is evident in studies such as the United States NSSE and Singapore's PETALS, which have utilized surveys on learning engagement to gather data on a wider range of students.The effectiveness of student learning in colleges and universities has been a topic of increasing concern in recent years. This is due to the pressure to ensure that students are receiving a quality education and acquiring the necessary skills and knowledge for success in their future careers(Yao Zhijian, 2018). In this regard , Yin Hongbiao (2016) summarized the existing research on the effectiveness of students' learning in colleges and universities. Research on education quality is generally divided into two categories: one is the survey of teaching quality from the perspective of course experience; the other is the survey of student behavior from the perspective of student engagement. Research on students' learning engagement has a great international influence. Many related studies have shown that learning engagement has a very important impact on the effectiveness of student learning. Research on learning engagement may be used as a part of the evaluation of learning effects. Research results in this area will be of great help to improve schools' online teaching and students' online learning process. Therefore, the shift from focusing on learner engagement in traditional education to engagement in online education platforms has become a hot topic in research in various countries.

1.1.2 The impact of investment in learning in colleges and universities on learning quality

1.The direct influence of student engagement on academic achievement is a crucial aspect to consider. Academic performance serves as a key metric for evaluating the effectiveness of students' learning, and there exists a strong correlation between engagement in learning activities and academic success. Studies indicate that active participation in learning positively affects academic performance. For instance, Wu Jiahui et al.(2023)'s research demonstrates a positive association between students' level of engagement in learning and their academic achievements. Actively participating in educational activities both inside and outside the classroom leads to higher levels of academic success, highlighting the importance of student involvement in their own learning process.The direct impact of learning engagement on knowledge acquisition.

2.The level of engagement in learning significantly influences knowledge acquisition. According to Yu Shengquan's (2007) findings, active participation in classroom discussions, critical thinking, independent learning, and similar behaviors positively correlate with knowledge acquisition among students. Furthermore, learning engagement is linked to students' information processing capabilities; dedicating more time and effort enables them to comprehend and internalize learned knowledge more effectively (Zhu Zhiting, & He Bin , 2012).

3. Learning engagement plays a pivotal role in shaping the learning experience of students. Actively participating in learning activities directly contributes to increased satisfaction and interest in learning. Zepke and Leach (2010) conducted research indicating a positive correlation between students' engagement in learning and their satisfaction with the course as well as their interest in the subject. Consequently, students

tend to derive greater enjoyment from the learning process, leading to heightened motivation to learn.

Learning engagement encompasses the active involvement, interest, and motivation exhibited by students throughout the learning process. It comprises various dimensions such as behavioral, emotional, and cognitive engagement, all of which significantly influence the learning strategies students adopt (Wang & Degol, 2014). Studies indicate that highly engaged students are inclined towards employing deep-level learning strategies such as deliberate practice, critical thinking, and knowledge integration.

In recent years, there has been a burgeoning interest in exploring the nexus between learning engagement and academic performance, as well as students' strategic choices in learning. Scholars in educational technology define learning engagement as students' level of involvement, interest, and commitment to their learning journey (Henrie et al., 2015). Multiple investigations have unveiled a positive association between learning engagement and academic outcomes. For instance, heightened engagement often correlates with improved grades, increased knowledge acquisition, and enhanced learning experiences.

1.1.3 Current status of blended learning among college students in China

Blended learning among college students in Chinese universities is undergoing rapid evolution, representing a dynamic and transformative field within education. Blended learning, also referred to as blended education or converged learning, amalgamates traditional face-to-face instruction with online distance education. It harnesses diverse educational resources and technological tools to enhance students' learning experiences and educational standards. This review examines the present state of blended learning for college students in Chinese universities, encompassing topics such as technology integration, instructional models, teacher-student engagement, learning motivation, and prospective trends.

1. Chinese universities have been progressively advancing the integration of information technology in education by introducing online learning platforms and educational tools. These platforms facilitate the dissemination of course materials by enabling teachers to upload content and students to engage in online learning activities.

Despite these advancements, variations persist in the quality of technology application and the richness of educational resources across different universities (Hu Tiesheng & Zhou Xiaoqing, 2014).

2. The conventional face-to-face teaching model is gradually transitioning towards blended learning in numerous colleges and universities. Institutions are experimenting with the integration of online education components, including video courses, online discussions, and assessments, to enhance students' learning encounters. This evolving model enables students to manage their study schedules more flexibly while enhancing the accessibility of educational materials (Hu Liru & Zhang Baohui, 2016).

3. The adoption of the blended learning model is reshaping the dynamics of teacher-student interaction. Traditional face-to-face interactions in classrooms are gradually complemented by online platforms such as online discussions, emails, and virtual office hours. This shift toward interactive online engagement affords students more avenues to interact with their instructors, thereby fostering increased engagement in the learning process (Yi Qinghong, 2015).

4. Blended learning fosters a sense of autonomy among students, requiring them to take greater responsibility for their learning process. This shift necessitates stronger motivation and self-management skills among students to effectively navigate learning tasks, which can pose challenges for some individuals. Consequently, the imperative remains to stimulate students' interest in learning and cultivate their autonomy to enhance overall learning engagement (Sun Yusheng et al., 2015).

5. The emergence of blended learning in Chinese universities has raised concerns regarding assessment and quality assurance. University leaders and educators grapple with the challenge of accurately assessing students' learning outcomes within a blended learning environment while ensuring consistency in educational quality. Addressing these issues poses significant challenges that require careful consideration and strategic planning (Zhao Juming & Gao Xiaohui, 2019).

6. The evolution of blended learning environments has necessitated a shift in the role of teachers, requiring them to adeptly utilize online education tools and teaching methodologies. To ensure effective instruction in blended courses, colleges and universities must offer comprehensive teacher training and ongoing support. Empowering

educators with the necessary skills and resources is crucial for successful implementation of blended learning initiatives (Chen Yiming, 2016).

1.1.4 The relationship between blended learning engagement and blended learning

Blended learning, as an educational approach combining traditional face-to-face instruction and online learning, demands substantial investment and support from universities to achieve success. The nexus between blended learning engagement and its implementation has garnered considerable attention in educational research. This article delves into this relationship, drawing on various authors and years to substantiate the discussion.

Successful integration of blended learning hinges on universities allocating significant resources toward technical infrastructure, faculty training, course design, and support systems. Garrison and Vaughan (2008) underscore that adequate teacher training and support are pivotal for achieving success in blended learning initiatives. Without proper guidance, educators may struggle to harness the full potential of this approach, potentially compromising educational quality.

Moreover, effective implementation of blended learning necessitates advanced technological facilities and robust online platforms. Wang Jinxu et al. (2018) emphasize the critical role of maintaining and updating technical infrastructure for the success of blended learning initiatives. Insufficient resources allocated to technology maintenance may result in technical challenges impeding the learning experience for both students and faculty.

Conversely, research by Means et al. (2013) highlights the numerous benefits of blended learning, including enhanced academic performance and student satisfaction. This underscores the potential for universities to elevate student learning outcomes through investment in educational quality.

In essence, the correlation between blended learning engagement and its successful implementation is evident. Universities must recognize that realizing the full potential of blended learning requires substantial resource allocation and support. This encompasses teacher training, technical infrastructure maintenance, course design, and support system establishment. By making these investments, universities can enhance educational quality, cater to student learning needs, and effectively implement blended learning methodologies.

1.1.5 Blended learning engagement assessment provides guarantee for the quality of blended learning

In recent years, researchers have increasingly focused on assessing students' engagement in blended learning environments. The widespread use of online platforms has expanded the range of learning behavior data that can be collected and analyzed. Empirical studies have explored the relationship between indicators of learning participation and academic performance across various teaching and learning contexts. For instance, Zhang Huainan (2019) found that participation in blended learning significantly predicts learning performance.

Furthermore, scholars have begun to delve into theoretical and practical approaches for analyzing and measuring students' engagement in blended learning (Yan, Y., & Chen, H., 2021). However, existing research on blended learning engagement analysis and evaluation still exhibits several shortcomings. Firstly, there is a dearth of comprehensive references regarding the composition, types, and evaluation of inputs in blended learning. While some studies have proposed evaluation models for online and face-to-face learning, their direct applicability to blended learning environments remains uncertain (Redmond, P. et al., 2018). Secondly, there is a lack of a mature investment analysis model specifically tailored for blended learning. While multidimensional models integrating learning behavior, motivation, and strategies have been proposed (Delialioğlu, Ö., 2012), their validation and refinement in practical settings are necessary.

Moreover, there is a scarcity of empirical research supporting the measurement indicators of engagement in blended learning. Although indicators such as online course participation rates, discussion frequencies, and online resource access have been proposed (Nguyen, Q., Rienties, B., & Richardson, J. T., 2020), their effectiveness in accurately reflecting students' engagement and its relationship with academic performance requires further empirical verification.

Consequently, exploring issues such as the analysis of blended learning engagement, the identification of effective indicators, and the impact of behavioral indicators on academic performance necessitates additional empirical studies. Future research endeavors can leverage large-scale data analysis and field surveys to deepen our understanding of the composition and determinants of blended learning engagement, ultimately establishing a comprehensive evaluation system and enhancing the quality of blended learning experiences.

1.1.6 The significance of engagement evaluation in blended learning

Blended learning, as an educational model, aims to merge traditional face-to-face instruction with online learning, offering students a more adaptable and personalized learning journey. However, for blended learning to thrive, colleges and universities must invest in educational resources, technical infrastructure, and teacher training. Evaluating blended learning engagement is pivotal to enabling institutions to comprehend and optimize the efficacy of these resources, refine educational quality, and cater to students' learning requirements. This study explores the significance of engagement evaluation in blended learning, drawing upon real authors and years to support this notion.

Successful implementation of blended learning demands substantial investment in technical facilities, online platforms, teacher development, course design, and support mechanisms. While the investment in these resources is indispensable, universities must ensure their efficient utilization to enhance educational standards. As noted by Hodges et al. (2020), careful planning and evaluation of blended learning inputs are essential to positively impact students' learning experiences. Evaluation of blended learning inputs aids universities in resource allocation management. By assessing the advantages of diverse resources, universities can identify areas requiring more investment and areas for enhancement, thus enabling more effective budget allocation and resource utilization.

According to Anderson et al. (2001), input evaluation of blended learning facilitates informed decision-making by colleges and universities to enhance students' learning experiences. Moreover, evaluation of blended learning inputs contributes to improving educational quality. Through monitoring and evaluating resource effectiveness, institutions can continuously refine course design, teacher training, and support systems to meet student learning needs, consequently enhancing educational quality and student academic performance and satisfaction.

As emphasized by Garrison and Vaughan (2008), assessing blended learning engagement enables colleges and universities to continually enhance teaching methodologies, thereby delivering a more efficient learning experience. In essence, blended learning input evaluation is crucial for the educational quality and resource management of institutions. It enables institutions to understand and optimize resource efficiency, improve educational quality, and meet students' learning requirements. Through comprehensive evaluation and feedback mechanisms, colleges and universities can continually refine blended learning implementation, offering students a superior learning experience.

1.2 Significance of the Study

The theoretical framework and methodological system of this study provide strong support for the design, quality monitoring, and evaluation of blended learning. By integrating various learning theories such as constructivism, social cognition, self-determination, humanistic learning, and self-regulated learning, we can gain a more comprehensive understanding of students' learning engagement in blended learning environments. This assists educators in better meeting students' learning needs, optimizing course design, and enhancing the quality of education.Additionally, the blended learning engagement model we have developed can serve as a valuable tool for educational assessment. It offers university instructors a systematic method for evaluating student engagement in blended learning. This is invaluable information for educators, aiding them in adjusting teaching strategies to better meet students' learning needs and improving teaching effectiveness. Importantly, the results of this study can provide practical tools and methods for measuring college students' engagement in blended learning. As blended learning becomes increasingly popular, understanding student engagement is crucial for educational institutions. Our research findings provide guidance for assessing college students' engagement in blended learning, helping educators gain a better understanding of students' learning attitudes and behaviors, as well as their performance in blended learning environments.

1.3 Purpose of the Study

1.3.1 To synthesize the Various indicators of the Blended Learning Engagement Evaluation System

1.3.2 To Identify Blended Learning Engagement Evaluation System for University in China.

1.4 Research Questions

1.4.1 What are the key elements in formulating the engagement level of blended learning in colleges and universities?

1.4.2 How to establish an evaluation index model for blended learning engagement in colleges and universities?

1.5 Theoretical Perspective

1.5.1 Constructivism theory emphasizes that students are active learners and construct their own understanding through interaction with knowledge and learning content. In blended learning environments, students construct knowledge through online resources, social interactions, and classroom experiences. Therefore, research can explore students' learning engagement in blended learning from a constructivist perspective, including how they actively participate in the knowledge construction process. Constructivism emphasizes students' initiative and participation in learning. Therefore, in blended learning, educators can promote students' learning engagement by designing inspiring and interactive learning activities.

1.5.2 Social cognitive theory emphasizes that learning occurs in a social environment, including interactions with teachers, classmates, and online communities. In blended learning, student social interaction and collaboration are critical to learning engagement. Research can explore how students collaborate with others, share knowledge, and develop learning skills in social interactions from the perspective of social cognitive theory. Social cognitive theory emphasizes students' ability to build knowledge and solve problems through participation in community and cooperative learning, therefore, blended learning can provide opportunities for students to actively participate in the social learning process.

1.5.3 Self-determination theory focuses on the impact of individual intrinsic motivation and external incentives on learning engagement. Research can explore students' learning motivation in blended learning environments, including their autonomy, attribution, and interest in learning tasks, to understand their level of learning engagement. Self-determination theory posits that students are more likely to be engaged in learning when their basic psychological needs (autonomy, competence, and relatedness) are met. Therefore, in blended learning, educators can stimulate students' intrinsic motivation by providing selective, challenging, and meaningful learning tasks, thereby enhancing their learning engagement.

1.5.4 Humanistic learning theory emphasizes that learning is a process that focuses on the emotions, emotions and personal growth of individual students. It emphasizes that learning is a process of individual subjectivity, and each student is unique and important. Self-concept and self-esteem are crucial to learning and growth. Learning should encourage students to pursue self-actualization, that is, reaching their highest potential. Students' autonomy and self-determination should be respected and supported. In blended learning, educators can promote student engagement by creating learning environments that support students’ emotional development and self-actualization. This can include encouraging students to explore their interests and passions and providing personalized learning opportunities to meet their individual needs.

1.5.5 Self-regulated learning theory emphasizes how students manage and control their own learning process to achieve more effective learning. Metacognitive theory emphasizes students' metacognitive strategies, that is, monitoring and adjusting their own learning process. Self-regulated learning is when students actively manage their learning by setting learning goals, choosing learning strategies, monitoring learning progress, and evaluating learning outcomes. They can adapt strategies to better suit different learning tasks and goals. Metacognition refers to the metacognitive strategies used by students, including planning learning, monitoring learning progress, and evaluating learning effects. Students use metacognitive strategies to understand their learning process, identify problems, and take steps to solve them. These two theories emphasize students' initiative and self-management ability to improve learning results. In blended learning, educators can encourage students to develop self-regulation and metacognitive skills to increase their learning engagement in both online and face-to-face learning environments.

1.6 Definition of Terms

1.6.1 Blended Learning

For blended learning, three common description methods are blended learning, mixed Learning and hybrid Learning. Researchers understand the definition of blended learning from multiple perspectives. Graham (2006) defined blended learning as a combination of face-to-face learning and online learning environments in "What is Blended Learning? Why Blended?" This is currently the most cited and recognized definition. However, while this definition is simple and clear, its implementation is highly complex, requiring solutions to nearly endless design possibilities and challenges applicable to a variety of environments. Harvi Singh and Chris Reed(2001)believe that blended learning optimizes the achievement of learning goals by using appropriate learning technologies to match appropriate learning styles and conveying the appropriate skills to the appropriate people at the appropriate time. Blended learning is a design idea that determines the optimal media or media combination based on learner characteristics and teaching objectives, and cooperates with appropriate modules or module combinations to achieve the best learning effect. Jennifer Hofmann (2002) believes that blended learning is presented to the appropriate audience through the optimal combination of media and modules to achieve the best learning effect. Michael Orey (2003) advocates exploring the definition of blended learning from the perspectives of learners, teachers and educational management, and taking into account factors such as equipment, tools, technology, media and teaching materials in order to achieve teaching goals.

Chinese researchers have different views when discussing the concept of blended learning. Zhu Zhiting and Huang Ronghuai(2013)believe that blended learning refers to the method of optimizing the selection and combination of teaching elements to achieve teaching goals, while Li Jiahou (2010) translated it as "integrated learning" and pointed out that its meaning is the application of various teaching methods. Optimize the combination of elements. He Kekang(2015)started from the role of teachers and students and believed that blended learning should not only give play to the leading role of teachers, but also fully reflect students' initiative, enthusiasm and creativity. Li Kedong(2012)believes from the perspective of educational communication that the essential feature of blended learning is to choose the channel for information transmission, and focuses on how to choose teaching media based on the principles of low investment and high efficiency.

Chinese researchers usually use "blended learning" and "blended teaching" synonymously. Li Manli believes that "in the domestic management and teaching context, blended teaching is the Chinese definition of blended learning ." John Daniel(2011)pointed out that in foreign studies, most researchers prefer to use the term “blended learning” to describe blended teaching. He believes that the term "blended teaching" is more suitable to describe teaching strategies. This study is described from the perspective of students’ learning , therefore, the term “blended learning” is preferred in the paper.

1.6.2 Learning engagement

Learning engagement refers to the extent and manner in which students participate in learning activities, including students’ behaviors and mentality of active participation in thinking, communication, exploration, reflection, etc. during the learning process (Appleton, Christenson, Kim, & Reschly, 2006). L earning Engagement is the psychological and behavioral engagement made by students in participating in learning, which includes three aspects: emotion, cognition and action, and also involves individual characteristics such as self-regulation, initiative and internal control. Fredricks, Blumenfeld, and Paris (2004) define learning engagement as “a positive state of students’ cognition, emotion, and action toward learning, including reasonable self-regulation strategies (such as attitude toward challenges, motivation to learn, ability to obtain help, etc.) and behaviors (such as taking the initiative to ask questions, participating in discussions, reading in depth, etc.).” Volet and Summers (2013) define it as students’ efforts and contributions in spirit, time, and actions during the learning process. Learning engagement can be divided into four levels: perceptual engagement (or emotional engagement), cognitive engagement, action engagement, and achievement engagement

(Reeve & Tseng, 2011). Research on domestic learning engagement began in the 1980s, and most studies focus on the current status and influencing factors of student learning engagement. Ding Peifen and Yuan Gang (2016) define learning engagement as “the behavior or psychological state of students during learning” and believe that it is a reflection of students’ subjective attitudes, emotional experiences and cognitive activities. Huan Hua (2019) defines it as " the process in which learning subjects actively use their own knowledge, abilities and experiences to participate in learning activities to improve learning effects, promote learning development and achievement achievement". In summary, the basic components widely accepted and recognized by scholars are behavioral engagement, emotional engagement and cognitive engagement (Gao, J., Li, M., & Zhang, W. (2015) . It is believed that learning engagement is a comprehensive Of these three dimensions of psychological state, behavioral engagement is the easiest to characterize and observe. It can be expressed through learners’ concentration, attention intensity, participation in classroom interactions, and interactions with teachers or peers (Liu, Q., Lei, S., Zhang, S., & Wang, Y., 2017). Learner’s Cognitive engagement refers to the cognitive strategies and metacognitive strategies used by students in the learning process, including autonomous The ability to construct a knowledge network, classify and memorize knowledge structures, summarize learning key points and apply them is the process by which students truly internalize learning content. emotional engagement mainly refers to the emotional attitude, motivation and interest generated by students during the learning process. It is one of the important indicators to measure students' learning patterns and whether they can achieve lifelong learning.

1.6.3 Chinese higher education

Chinese higher education refers to academic and vocational training activities conducted in various higher education institutions in China. It includes undergraduate education, graduate education, continuing education, and research work in various subject areas. Chinese higher education system is diverse, covering many types of institutions such as universities, colleges, and research institutions. This education system aims to cultivate students' academic abilities, vocational skills and social responsibility, providing a foundation for their future careers and social participation. Our study here involves undergraduate education.

1.6.4 Evaluation indicators

Evaluation indicators are specific standards, elements or measurement methods used to measure, evaluate or evaluate a thing, process, project or performance. These indicators are often based on specific goals, standards or expectations and provide information about quality, effectiveness, progress or success. Evaluation metrics are widely used in a variety of fields to determine whether specific goals have been achieved, provide decision support, improve performance, or monitor progress. This definition covers the main characteristics of evaluation indicators, including their uses, properties and broad areas of application. In specific contexts, evaluation indicators can be specific to a certain area or task and used to quantify and evaluate performance, quality, or progress.

1.6.5 AHP

The Analytic Hierarchy Process, abbreviated as AHP, is a practical multicriteria decision-making method that was proposed by Professor T. L. Saaty in the early 1970s.It is a tool designed to simplify complicated and unstructured circumstances, particularly suitable for problems that are difficult to analyze quantitatively. AHP allows decision-makers to systematically integrate different components of evaluation criteria in various contexts, such as English language teaching materials evaluation (Kato, 2013). AHP is particularly useful in decision-making scenarios where multiple objects need to be compared and ranked based on their importance.By using the AHP, decision-makers can effectively prioritize and weigh the different evaluation criteria and make informed decisions based on a comprehensive analysis of the various components involved (Vaidya & Kumar, 2006).

1.7 Limitations of the Study

The study presents several limitations:

1.7.1. Expert Limitation: The findings are derived from a specific group of experts, all of whom possess a PhD or have served as Assistant Professors for at least five years. This composition may restrict the breadth of perspectives due to the experts' backgrounds and experiences.

.7.2. Analyst Bias: The interpretation and presentation of the study's results may be influenced by analyst bias. The researcher's personal views and experiences could shape the analysis, potentially compromising the objectivity of the research.

1.7.3. Communication Method: The study relied on email communication, and experts received the questionnaire upon onboarding. This mode of communication might affect the experts' responses and engagement levels, as face-to-face interactions tend to be more interactive and detailed.

1.7.4. Geographical Limitations: The study's scope may be constrained by geographical limitations. Variations in educational systems and cultural contexts across regions could impact students' learning engagement and characteristics. As the study focused on colleges and universities in Sichuan Province, China, its generalizability to other regions may be limited.

These limitations could affect the study's external validity, objectivity, and applicability. Researchers should consider these constraints when discussing the study's findings and formulating recommendations.

1.8 Expected benefits

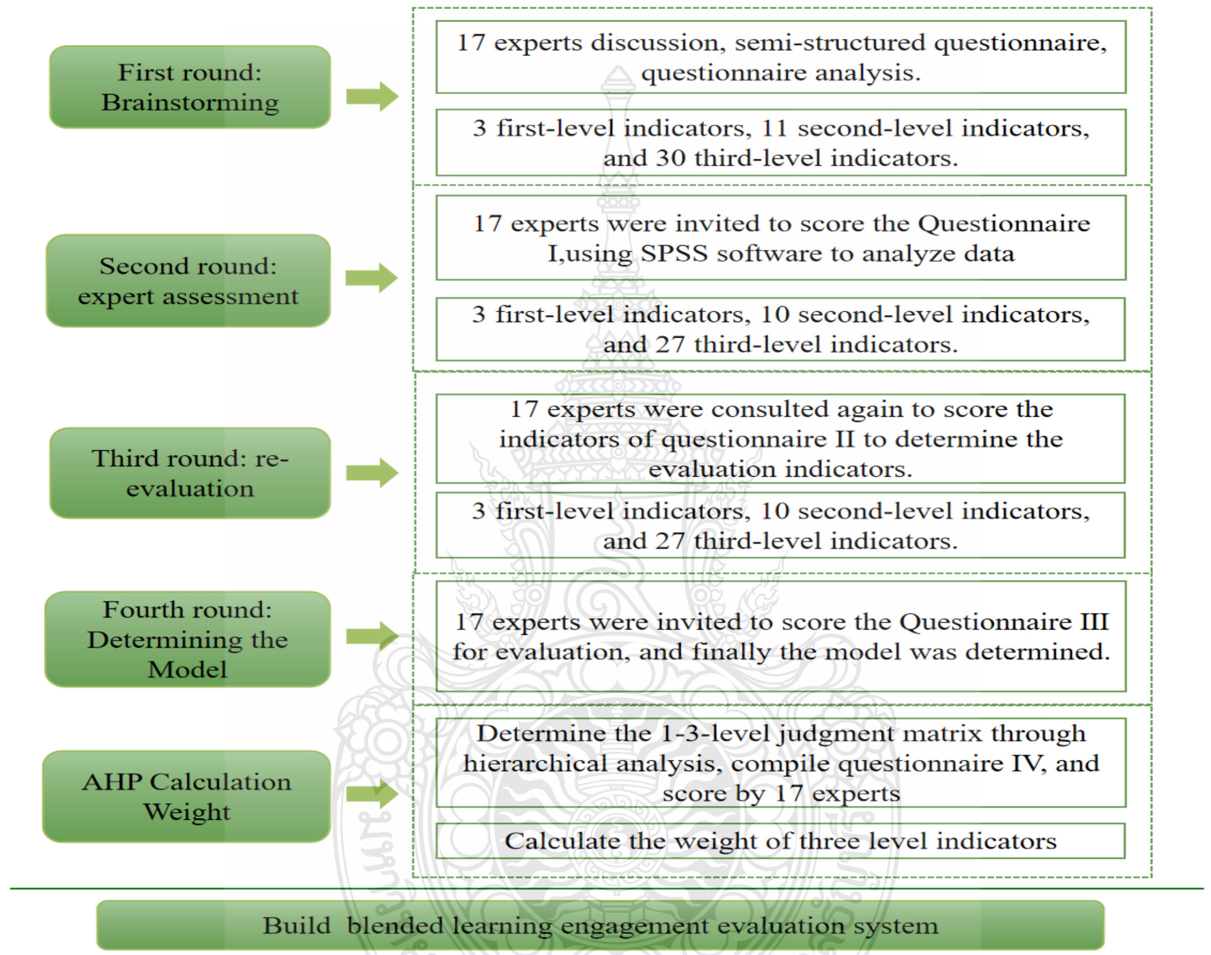
1.8.1 This study will build an evaluation system for blended learning engagement in Chinese universities.

1.8.2 This research helps to understand college students’ investment in blended learning, so as to propose targeted strategies to increase university learning engagement and improve the quality of blended learning.

1.9 Research process framework diagram

The study uses Delphi technology to construct a blended learning engagement evaluation framework in colleges and universities, and uses the AHP method to calculate the weight of the evaluation system to obtain the final evaluation system.

Figure 1.1 Blended learning engagement evaluation system construction flow ch


First round: Brainstorming
17 experts discussion, semi-structured questionnaire, questionnaire analysis.
3 first-level indicators, 11 second-level indicators, and 30 third-level indicators.
Second round: expert assessment
17 experts were invited to score the Questionnaire I,using SPSS software to analyze data
3 first-level indicators, 10 second-level indicators, and 27 third-level indicators.
Third round: re-evaluation
17 experts were consulted again to score the indicators of questionnaire II to determine the evaluation indicators.
3 first-level indicators, 10 second-level indicators, and 27 third-level indicators.
Fourth round: Determining the Model
17 experts were invited to score the Questionnaire III for evaluation, and finally the model was determined.
AHP Calculation Weight
Determine the 1-3-level judgment matrix through hierarchical analysis, compile questionnaire IV, and score by 17 experts
Calculate the weight of three level indicators
Build blended learning engagement evaluation system

CHAPTER 2 LITERATURE REVIEW

The introduction complements the goal of this chapter. This chapter will contribute further to the literature review during the study's design and enhance learner engagement in blended teaching. This chapter is divided into the following parts:

2.1 A theoretical perspective of the blended learning engagement
2.2 Blended Learning Research
2.3 Research on learning engagement
2.4 Research on evaluation indicators of learning engagement
2.5 Delphi

2.1 A theoretical perspective of the blended learning engagement

2.1.1 Metacognition Theory

American psychologist Paul Pintrich(1990). introduced the concept of autonomous learning and metacognition.The concept of self-directed learning has greatly influenced the field of education by highlighting the significance of students' active involvement in their own educational journey. This method fosters student engagement, emphasizes the value of education, and nurtures confidence in their personal skills and attributes.(Ni, 2020).

Autonomous learning, also referred to as self-directed learning, is a educational approach that centers on the learner's independence and capacity for self-regulation. In this strategy, learners play an active role in their own educational journey by defining objectives, choosing study materials, and assessing their advancement. This method underscores the significance of metacognition - the learner's cognizance and comprehension of their personal learning process. Metacognition enables learners to contemplate their learning techniques, oversee their comprehension, and make modifications as necessary. Improving these metacognitive abilities can enable learners to enhance the efficiency of their academic endeavors(Mitsea & Drigas, 2019).These approaches can be modified based on the type of learning activity to enhance academic outcomes. Students must actively manage their cognitive and educational procedures, which contributes to enhancing their learning efficacy and productivity. Moreover, students should have the ability to assess the effectiveness of their chosen learning strategies and make modifications as needed(Zhao Yiquan , 2003). This feedback loop supports learners in consistently enhancing their methods of learning. Metacognition involves individuals having a deep understanding of their own cognitive processes and the ability to manage these processes. Drawing from relevant theories, scholars developed a model for metacognitive monitoring to thoroughly investigate how metacognition monitors and controls the acquisition, retention, and recall of knowledge. Furthermore, other experts have also suggested comparable self-regulation models that underscore the significance of metacognition in cognitive processes.(Kolb & Kolb,2008).Researchers suggest that metacognition comprises five key processes: planning and implementing strategies, monitoring strategy steps, experimenting with strategies, adjusting strategies, and assessing strategies. These processes highlight the significance of individual self-regulation and self-control in cognitive tasks.(Sun Fengjuan, 2006). From the viewpoint of contemporary cognitive psychology, metacognition is intricately connected to self-awareness, which plays a pivotal role in driving students' active learning. Consequently, metacognition serves as a fundamental requirement for achieving independent learning. Furthermore, within autonomous learning contexts, metacognition manifests as a method for regulating one's decision-making processes. Skinner(2009) suggests that autonomous learning encompasses four key processes: self-monitoring, self-guidance, self-evaluation, and self-reinforcement.Zimmerman (1986)'s research on the self-regulation of metacognition from a social cognition perspective emphasizes the importance of considering metacognition, motivation, and behavior when assessing a student's ability to learn independently.Chinese scholar Zhu Zhixian (1981) first introduced the concept of metacognition as the self-awareness and self-regulation of an individual's cognitive processes. This introduction has sparked extensive research into metacognitive theory in China, with a focus on understanding its connotation, structure, and the three main elements involved. Additionally, researchers have highlighted the significance of metacognitive monitoring and recognize its crucial role in education by improving students' ability to acquire knowledge and informing future educational practices.

In short, self-directed learning and metacognitive theory offer a strong educational framework that prompts learners to take an active role in managing and adapting their own learning processes. Through the utilization of diverse learning techniques and metacognitive abilities, learners can enhance their efficacy in learning, leading to improved academic performance. This theoretical approach equips educators and students with valuable resources for enhancing education and learning outcomes.

2.1.2 Constructivist learning theory

Constructivism is a learning theory that centers on the learner and highlights self-construction and the active building of knowledge during the learning process. According to Jonassen and Land, this theory underscores learners' active involvement in acquiring knowledge, emphasizing their role as creators rather than just recipients of knowledge. Learners are tasked with taking responsibility for constructing their own understanding throughout the learning process by interpreting new information, integrating it with existing knowledge, and progressively expanding and reshaping their cognitive frameworks to achieve deeper comprehension and skill enhancement(Thanh, 2016).

Early scholars such as Piaget (1970) and Vygotsky (1978) believed that constructivism also emphasized the interaction between learners, teachers, classmates and the learning environment. Learners construct new knowledge and concepts through interaction with the environment, and deepen and expand their knowledge through interaction with teachers and classmates. Teachers and classmates play an important role in this process. They can provide feedback, stimulate thinking, and pose challenges, thereby helping learners better understand and master new knowledge and skills.The constructivist theory offers a versatile framework suitable for application in diverse fields including education, psychology, and technology. Its emphasis on learner motivation and self-direction has the potential to significantly improve educational experiences by promoting deeper understanding and skill acquisition. This approach acknowledges the individuality of each learner, considering their unique knowledge structures and learning preferences. Educators can leverage constructivist principles to create tailored and captivating activities that address learners' specific backgrounds and needs, ultimately fostering effective knowledge construction and successful learning results.(Yang & Wu, 2012).Vygotsky emphasized the significance of social interactions and cultural influences in cognitive development, proposing that learning is a collaborative social process. Bruner also enhanced constructivism by underscoring the roles of culture and language in knowledge construction. Despite various strands of constructivist theory, they share fundamental concepts regarding knowledge, students, learning, and teaching to form a cohesive set of cognitive learning theories. Since the 21st century, there has been substantial interest in educational research on constructivist learning theory. Books such as "Constructivism in Education" and "Constructivist Classroom Teaching Cases" delve into specific applications of constructivist theory for teaching practices, offering valuable insights for educators. In China, constructivist learning theory emerged in the 1990s. Current domestic research predominantly focuses on theoretical interpretations and explanations of constructivism as well as its application within local education to guide curriculum reform efforts.(Ma Shuangyuan , 2022).

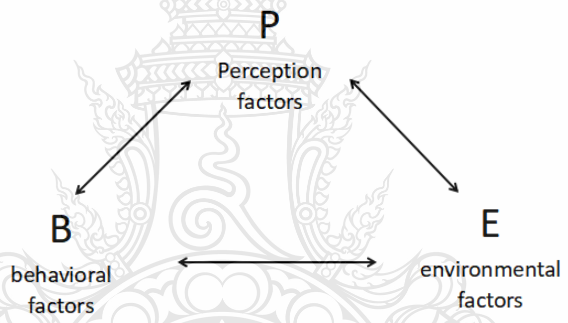
2.1.3 Humanistic Learning Theory

Humanistic learning theory is a significant educational concept that highlights the importance of tailoring the learning process to an individual's emotional and spiritual journey. This perspective argues that learning goes beyond mere knowledge transfer, emphasizing instead a deep process of self-discovery and personal development. In humanistic theory, learners are seen as active individuals with their own unique experiences, highlighting the significance of subjective perspectives. Carl Rogers and Abraham Maslow stand out as key proponents of humanistic learning theory, advocating for individuals' pursuit of self-actualization and personal fulfillment. As such, this approach emphasizes creating a positive and supportive environment in which learners can explore their potential and achieve self-improvement.(Cristea, 2015).According to humanistic learning theory, the learner's needs and motivations play a critical role. It is essential for learners to experience acceptance and respect in order to develop confidence and self-esteem. This nurturing environment enables learners to reach their maximum potential by promoting independent thinking and exploration, as opposed to passively receiving information. Consequently, students are able to engage in self-discovery, further understanding their own interests, values, and aspirations. Additionally, humanistic learning theory stresses the significance of individual subjective experiences in education.(Green & Gredler, 2002). Learning involves more than just cognitive development; it also encompasses emotions and the creation of meaning. Learners should be given opportunities to explore their emotional reactions, contemplate their experiences, and incorporate these reflections into the learning process. This personalized approach to learning assists learners in constructing deeper comprehension and forming more enduring memories. In philosophy, Protagoras from ancient Greece's Sophist School advocated for "human-centered" values and emphasized human significance as supreme. He posited that humans are the standard by which everything in the world is measured, not only regarding existence but also non-existence.(Jia, 2010). Ancient China's "Guan Zi Ba Yan" also conveyed the concept of prioritizing the needs of individuals and placing importance on human nature. These ideas carry forward the fundamental principle of "humanism," with profound reflections of Confucian teachings on "benevolence." In contemporary philosophy, existentialism is a manifestation of humanistic thought, highlighting individual freedom, choice, responsibility, and potential for growth.(Staver, 1998). Rogers stressed the importance of educators comprehensively understanding students' unique characteristics and creating non-directive teaching strategies to support their learning and development. Humanism focuses on addressing the holistic growth and emotional requirements of students in education reform. Essentially, humanistic learning theory underscores the distinctiveness and personal experiences of each learner, emphasizing that the learning process should offer opportunities for self-exploration, self-actualization, and self-improvement while ensuring support and consideration for their emotional and cognitive needs. This theory significantly influences educational practices and the creation of learning environments, potentially fostering learners' intrinsic motivation and enthusiasm for learning, leading to more comprehensive individual advancement(Jia, 2010).

2.1.4 Social cognitive theory

Albert Bandura proposed the Social Cognitive Theory, which examines how individuals gain and assimilate behaviors by observing and imitating others(Nabi & Prestin, 2017). According to the provided sources, Social Cognitive Theory, introduced by Albert Bandura, is an influential theory in social psychology. It underscores the significance of observing, modeling, and replicating the behaviors, attitudes, and emotional responses of others. This theory proposes that individuals learn not only through direct reinforcement but also by watching others and imitating their actions. Additionally, Social Cognitive Theory emphasizes self-efficacy as a belief in one's capability to effectively perform actions. Self-observation can influence human behavior; individuals can establish their own behavioral standards and assess them by observing others' performances.(Cristea, 2015).An individual's actions are influenced not only by their personal powers of observation but also by external and social circumstances. Social cognitive theory posits that behavior can be replicated, particularly in a structured setting such as classroom learning. In the 1986 publication "Social Basis of Thought and Behavior: Social Cognition," the author introduces a theoretical model for understanding an individual's motivation, thoughts, and actions based on social cognitive perspectives, providing a comprehensive analysis and summary of the theory of social cognition(Bandura, A ,2001) . According to the social cognitive perspective, human behavior is influenced by a combination of internal and external factors. Bandura's triadic interactive determinism model illustrates this concept, as shown in Figure 2.1. Bandura extensively discussed social cognitive theory and introduced the idea of triadic interactive determinism, where cognitive factors are denoted as 'P', behavioral factors as 'B', and environmental factors as 'E'. These three elements interact with each other, symbolized by two-way arrows. Behavioral, cognitive, and environmental components all play a role in determining behavior within the framework of interactive determinism(Bandura,A.,1977). The three-dimensional interactive determinism model has been extensively utilized across various disciplines, typically employed for examining the link between cognitive elements and behavior. Initially, numerous researchers concentrated on studying issues related to computer proficiency. Compeau and Higgins explored the training process for computer skills, formulated a research framework to examine the utilization of social cognitive theory, and deliberated on the influence of cognitive factors on behavioral outcomes.(Compeau, DR, & Higgins CA, 1995) . Performance expectations are strongly linked to usage behavior, and individual differences play a crucial role in shaping the influence of each factor. Success in learning is associated with enhanced self-efficacy perception, which in turn boosts one's ability and motivation to pursue goals. As such, fostering self-efficacy is a key objective of social cognitive theory, which underscores the significance of the environment as well as individual self-efficacy and adaptability. Observational learning, imitation, and reflection are highlighted as ways through which individuals acquire new behaviors.(Loyens & Gijbels, 2008) .Based on Bandura's social cognitive theory, Compeau and Huff discovered that people's cognitive beliefs about computers, personal expectations, and performance expectations play a role in influencing their computer usage behavior.(Compeau, D., & Huff HS 1999) .

Figure 2.1 Three-dimensional interactive determinism model diagram



2.1.5 Self-Determination Theory

Self-determination Theory, referred to as SDT, was proposed by American psychologists Deci and Ryan (2000).The Theory of Individual Intrinsic Motivations and Social Development discusses the inherent drives that lead individuals to pursue new experiences, confront challenges, and achieve personal development. It comprises five sub-theories: The Basic Needs Theory suggests that social situations impact behavior, psychology, and personality development by fulfilling individuals' three fundamental psychological needs. Additionally, the Cognitive Evaluation Theory explores how various social situations influence internal motivation in individuals. The Organismic Integration Theory distinguishes between extrinsic and intrinsic motivation, categorizing extrinsic motivation into four types based on the level of self-determination. Moreover, the Causality Orientations Theory classifies motivational orientation into autonomous orientation, control orientation, and impersonal orientation from a personality perspective to illustrate stable differences in individual motivation. Finally, the Goal Contents Theory delves into intrinsic goals and their correlation with external goals as well as individual mental health and happiness; it identifies varying effects of different goal contents on motivation and happiness.The complete self-determination theory consists of five sub-theories, with the basic psychological needs theory serving as its foundation(Reeve, J., 2012).Deci and Ryan suggest that humans have an inherent drive to pursue psychological growth and integration across their abilities, value realization processes, and social relationships. According to SDT, it is posited that every individual, irrespective of gender, age or other attributes, possesses fundamental psychological needs. These innate needs can account for a person's behaviors or lack thereof and are crucial for ongoing physical as well as mental health development along with overall well-being(Deci, EL, & Ryan, RM 2000). According to SDT, fundamental psychological needs comprise the necessity for independence, connection, and proficiency. The requirement for independence entails individuals' desire to determine their own actions, have authentic experiences, and validate themselves. In this context, "independence" is not in opposition to "reliance". It encompasses not only an individual's choice to act based on their own volition but also underscores that personal behavior should be endorsed and acknowledged by others. Within an educational setting, students should have the freedom to make decisions independently while receiving essential social support from educators, peers, and parents. The need for competence pertains to individuals desiring opportunities within social interactions where they can exercise and demonstrate their capabilities. This capability does not revolve around acquiring skills or competencies; rather it involves feeling self-assured and effective in one's actions(Reeve, J., Deci, EL, & Ryan, RM 2004).Research indicates that praising abilities can boost internal motivation, whereas criticism may diminish it. The need for connection encompasses the desire to form close emotional bonds with others and feel cared for, supported, understood, and included in one's environment. In an academic setting, when students build positive and stable relationships with teachers, peers, and parents, this need is met which in turn improves their sense of belonging as well as academic involvement and overall well-being(Reeve, J., Deci, EL, & Ryan, RM 2004).

2.2 Blended Learning Research

2.2.1 The proposal and connotation of blended learning

2.2.1.1 Proposal of blended learning

Elaine Voci and Kevin Young (2001)defined blended learning as the combination of various learning time, environments, resources, methods, etc., in order to leverage the benefits of both traditional classroom instruction and contemporary online learning. This approach aims to optimize the overall impact on student learning. The concept of blended learning was initially explored in depth within the "Blended Learning White Paper" released by an Indian IT firm. Blended learning has sparked great interest in many academic circles and research institutions, leading to a more scientific definition. In the field of business training, American training facilities early on identified the goals of blended learning as developing employees' communication skills, ability to handle complex tasks, providing personalized learning experiences, and promoting collaborative team learning to achieve corporate performance objectives(Singh, 2001). Blended learning has been defined in various ways by different researchers. Ole highlighted that it involves the systematic arrangement and efficient utilization of educational resources to meet instructional objectives, while also aligning with students' individual learning preferences and cognitive frameworks(Project NH, 2013). According to Harvi Singh and Chris Reed, blended learning encompasses various aspects such as incorporating both traditional classroom settings and online instruction, integrating individualized content with group-based collaborative learning, combining structured and unstructured educational approaches, the fusion of learning with personalized instructional methods, and linking work experiences with study pursuits.(Vaughan, 2007). Blended learning involves combining various learning methods, technologies, and environments. In China, research on blended learning began in 2003. Professor He Kekang asserts that blended learning maximizes the benefits of face-to-face and online learning, promotes independent study among students, fosters innovation, and effectively integrates both approaches.(He Kekang, 200 5) . Professor Li Jiahou highlighted that blended learning involves effectively integrating different teaching elements, requiring both teachers and students to adeptly utilize a variety of instructional technologies, approaches, and tactics in order to accomplish educational objectives.(Li Jiahou, 2004). Professor Li Kedong highlighted that the primary objective of blended learning is to address challenges and accomplish educational objectives in an efficient and expedited manner, while optimizing advantages throughout the teaching journey(Li Kedong, 2004). The emergence and evolution of blended learning signify significant shifts in the acquisition and dissemination of knowledge within the realm of education. Throughout various historical eras, from agricultural to industrial to the present Internet age, there have been substantial transformations in educational methods and objectives for talent development. The concept of blended learning encompasses not only the combination of face-to-face and online instruction but also serves as a response to the evolving nature of knowledge enrichment in the digital era, as well as a way to cater to diverse talent demands. It empowers educators to move beyond mere technological considerations and instead concentrate on enhancing students' capabilities while fostering personalized, student-centric learning environments. As "Internet+" becomes integrated into this concept, it continues to broaden its scope(Hartfield,2013).Learning today goes beyond just online and in-person instruction, as it incorporates diverse learning approaches, resources, content, instructional models, and support services to optimize the learning experience (Feng Xiaoying,2018). Different scholars and researchers have provided their perspectives on blended learning, covering educational methods, goals, and its evolution from teaching approaches to student experiences.

2.2.1.2 The connotation of blended learning

Face-to-face classroom learning has a long history and has played a significant role in the progress of human society over the centuries. With the advent of the Internet age, new ideas from information technology and network connectivity have rejuvenated traditional face-to-face learning methods. Previously, face-to-face and online learning were separate entities, utilizing distinct teaching tools and approaches to cater to diverse learners' requirements. In traditional face-to-face instruction, interaction between students and teachers at specific times and locations was essential, often entailing teacher-led continuous learning using static teaching materials(Huang, 2021). Online education utilizing the Internet allows both students and educators to break free from constraints of time and place. It offers a wide range of learning materials, interactive tools, and multimedia technologies that significantly stimulate learners' engagement and participation. For instance, online education features interactive reading materials, online discussions, live chats, collaborative platforms like wikis, educational games and quizzes for assessment purposes as well as authoring tools along with video and audio resources - all contributing to rejuvenating the learning process(Kuo et al., 2014).Face-to-face traditional classroom instruction typically facilitates active student engagement and enables teachers to organize and oversee the learning process. Teachers assume a prominent role in offering real-time assistance through direct communication, thereby fostering an immersive educational environment(Kuo et al., 2014).Virtual online learning offers students abundant learning materials and a flexible learning environment, enabling students to tailor their own study schedule based on their preferred learning approach, thus fostering motivation for learning.(Shi,2020).Blended learning effectively combines these two educational approaches with the aim of optimizing engagement and effectiveness while ensuring a high-quality learning experience. In summary, blended learning is an instructional model that prioritizes individualized education and holistic development by leveraging the strengths of in-person instruction and online resources, all underlining the important role of educators. It encompasses diverse teaching methods, tools, course materials, resources, strategies, and assessment techniques to emphasize integration for optimal results. While rooted in traditional and online learning components, its distinctiveness lies in its focus on tracking learner progress, personalized lesson plans, instructional design approach, as well as evaluating learning outcomes(Prifti, 2020).

2.2.2Research status and development trends of blended learning

2.2.2.1 Research status of blended learning

The ERIC sub-database within the EBSCO academic resource retrieval platform was utilized by the researcher to conduct a search limited to 2023. The source type selected was "academic theoretical journals," and the search terms used were "blended learning" and "blended learning," resulting in a total of 23,279 retrieved documents. Analysis of author distribution in the literature indicates that most blended learning researchers are based in countries like the United Kingdom, United States, Spain, Germany, Australia, and Canada. This suggests that European and American nations hold prominent positions in international blended learning research, while relevant studies from Asian countries lag behind. Furthermore,the study shows multiple areas such as basic education,higer education,coprate training & medical educations have seen extensive attention towards international Blended Learning indicating it's growing significance into various fields(Devi et al., 2021).There is a broad concern regarding the design, creation, execution, and assessment of blended learning. Furthermore, ongoing research in the field of blended learning concentrates on fundamental areas like developing blended learning environments, creating blended learning courses, and establishing models and techniques for blended learning(Yu Xian et al., 2013). In terms of course design for blended learning, Carman JM (2002) proposed five key factors for blended learning process design: synchronicity, online learning content, collaborative communication, evaluation, and learning transfer. Synchronicity requires teachers and students to participate in learning at the same time and space, while online learning content supports learners' independent learning anytime and anywhere. In addition, the blended learning environment must promote in-depth communication among learners, effectively evaluate learners' learning situations and the effectiveness of learning methods, and ultimately provide teaching materials that can promote learning understanding and transfer.In the context of designing courses for blended learning, Carman JM(2002) identified five essential elements for designing the process of blended learning: synchronous participation, online educational materials, collaborative communication, assessment, and knowledge transfer. Synchronous participation necessitates both teachers and students engaging in learning activities simultaneously and within a specific space. Online educational materials facilitate independent learning for learners at any time and location. Moreover, the blended learning environment should encourage extensive communication among learners, assess their progress effectively, appraise the efficacy of teaching methods used by them to gauge their understanding， and finally provide instructional resources that enhance comprehension and application of knowledge.As for the models and approaches to blended learning, well-respected scholars such as Staker and Horn outlined four application models of blended learning after studying 80 US K-12 stage blended learning projects. These include conversion mode (comprising in-place conversion, computer room conversion, flipped classroom, and individual conversion mode), flexible mode, menu mode, and enhanced virtual mode(Bai Xuemei et al., 2016). Liz Arney's publication "Go Blended!: A Guide to Introducing Technology in Education" provides comprehensive guidance on incorporating blended learning into educational institutions. It delves into the stages of preparation, planning, and implementation, addressing challenges and offering solutions from various viewpoints.(Kristianingrum & Widyantoro, 2020). Inkeri Ruokonen(2016) created a technology-infused blended learning approach for music education, finding that this method supports meaningful learning. American researchers McLaughlin JE et al(2015) highlighted the significance of integrating online learning with traditional classroom instruction. Additionally, they underscored that blended learning yields a favorable impact on enhancing academic achievement.Lopez-Perez (2011) carried out research on the efficacy of blended learning, focusing on practices at the University of Granada.The findings indicated that blended learning decreased the rate of school student attrition, enhanced academic achievement among students, and was associated with factors such as grades, personal background, and attendance. Pennsylvania State University holds a positive view of blended learning and considers it an unavoidable trend in higher education(Barnum. C. & Paarmann, W., 2002). Some globally recognized corporations, including IBM, SONY, and Nokia, have effectively implemented blended learning in corporate training to achieve anticipated advantages such as reduced training expenses and successful fulfillment of training objectives. In a study by Tomson comparing the effects of blended learning and online learning on employee productivity, it was found that employees utilizing blended learning exhibited higher work efficiency compared to those exclusively using online learning(Ye Zuojun, & Zhou Jiao , 2023) .

Blended learning as an educational approach has garnered widespread global attention and research, demonstrating considerable promise across various disciplines. Scholars and academic institutions from diverse nations continue to investigate optimal strategies for blended learning in order to enhance the quality of education and academic achievements.

2.2.2.2 Blended learning research trends

Research on blended learning trends in China's domestic sphere has demonstrated distinct and noteworthy patterns, attracting significant interest in academic and educational communities. Here is a detailed summary of these observed patterns:

1. Academic Focus on Learning Engagement: Scholars have recently turned their focus to the issue of student learning engagement, recognizing it as an essential element in enhancing learning outcomes. Studies typically involve assessing students' cognitive, behavioral, and emotional engagement within blended learning settings and suggesting appropriate enhancement approaches. This emphasis underscores the importance of learner independence and motivation for the effective execution of blended learning(Sun Yusheng et al.,2015).
2. The utilization of mixed reality technology in blended learning has emerged as a leading area of research. Mixed reality technology offers new potential for education due to its advanced three-dimensional visualization and interactive capabilities between humans and computers. Its adoption in fields like medicine, engineering, and chemical experiments is driving the advancement of blended learning(Cai Su et al.,2016).
3. Deep learning has emerged as a key area of interest in the realm of blended learning research. It involves students actively and critically engaging with knowledge to deepen their understanding and construct new insights. Scholars are dedicated to investigating the integration of deep learning within blended learning settings, with a specific emphasis on designing courses and incorporating best practices across various academic subjects and domains(Peng Lei et al ,2022) .
4. The development of essential skills among students is a primary goal in blended learning. It has become crucial to improve core competencies across various disciplines in higher education, leading to the need for blended learning programs that focus on these competencies. As a result, there has been an increase in the creation of high-quality, advanced blended courses within higher education (Ouqun., 2015) .
5.The usage of the community of inquiry model is widespread in blended learning, emphasizing collaborative constructivism and the development of students' critical thinking and higher-order cognition. While there are limited studies on this topic in China, a few scholars have extensively investigated this area.(Yin Mingzhang et al.,2021).

2.2.3 Advantages of blended learning

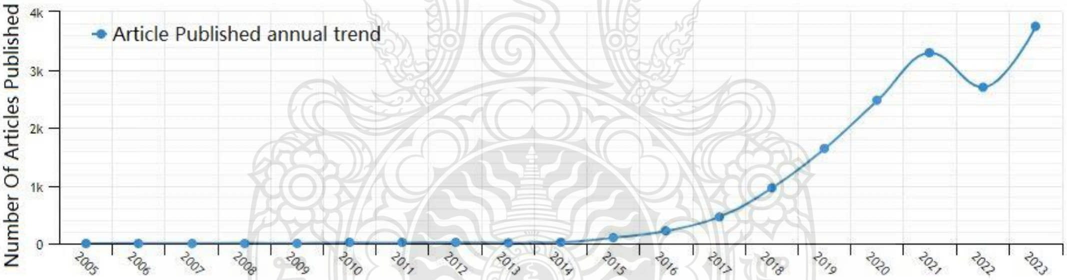
The high attrition rate in online education and the tendency for students to experience feelings of isolation have been a focal point within the academic community. Kranzow suggested that this occurrence could be linked to the absence of in-person interactions and guidance from instructors, leading to lower satisfaction among students with online learning compared to traditional face-to-face courses(Mullen & Tallent-

Runnels, 2006). Blended learning has recently become prominent in the education sector by merging conventional in-person teaching with online instruction, aiming to address the limitations of both traditional and digital methods. This approach has garnered significant interest(Wang, 2019). Blended learning goes beyond the constraints of traditional teaching in terms of resources, time, and location. It also addresses the deficit of emotional support found in pure online learning by combining the strengths of both approaches. In comparison to traditional face-to-face and pure online learning, blended learning facilitates synchronous interactions among students, thus enhancing learners' overall satisfaction with their educational experiences(Owston, York, & Murtha, 2009). A 2009 empirical research analysis conducted by the U.S. Department of Education, which examined higher education research from 1996 to 2008, found that blended learning was identified as the most effective method of learning, followed by online learning. In comparison, traditional face-to-face teaching was deemed to be the least effective approach(Zhan & Li, 2009). This research outcome once again demonstrates the strong efficacy of blended learning. What are the benefits of blended learning? Firstly, blended learning aligns with the educational philosophy of "student-centered and teacher-guided" practices(He, 2004). Traditional in-person instruction typically focuses on the teacher as the central figure, leading the teaching process. On the other hand, blended learning places greater emphasis on "teaching students according to their individual abilities," thereby highlighting the dominant role of the student. In this approach, teachers are responsible for guiding, motivating, and overseeing the learning process to offer more personalized educational support to students. Additionally, blended learning enables learners to tailor their own pace of learning, which enhances both interest and effectiveness in acquiring knowledge. By organizing their study time based on personal learning needs and speed, students can stimulate their motivation for academic pursuits through this autonomy(Kristianingrum & Widyantoro,2020).Teachers can contribute to the blended learning process by offering students learning structures, methods, and guidance on time management, which ultimately enriches the overall learning experience. Additionally, blended learning aligns with Schramm's law of media selection (Li & Zhao, 2004).Teachers and students can select suitable media and educational tools based on learning goals and content characteristics to minimize costs while maximizing learning outcomes. This customized approach supports diverse learners' needs, enhances teaching flexibility, and adaptability. Blended learning has significantly advanced education by addressing the drawbacks of both online and face-to-face instruction. It offers a more personalized, adaptable, and effective way of learning that leads to higher learner satisfaction. As such, blended learning holds great promise for driving innovation in education into the future.

2.2.4 Research progress in blended learning in China

In recent times, researchers from China have extensively studied blended learning and investigated innovative educational approaches that integrate online and in-person classroom instruction. Progress in this area of study has been substantial and offers valuable insights for the advancement of education in China. This article performs a thorough literature review using the China National Knowledge Infrastructure database, focusing on the keyword "blended learning". It conducts an annual analysis of related research literature to uncover emerging trends in the field of blended learning research.Figure 2.1 illustrates the evolution of blended learning research in China. From 2005 to 2014, Chinese scholars produced numerous research papers on blended learning, marking the field's initial phase. Subsequently, from 2015 onwards, there was a substantial increase in blended learning research output. By 2023, the number of related articles had surged to nearly 4,000—an indication of widespread interest and ongoing investment by Chinese academic institutions. Of particular note is the adoption of online education platforms by Chinese schools during the COVID-19 pandemic which has spurred increased focus on ensuring quality and effectiveness of online courses. Consequently, there has been a significant rise in articles related to blended learning since then as researchers actively explore optimal practices for remote education delivery.It is anticipated that there will be further expansion in the realm of blended learning research. With technological advancements and ongoing evolution of education models, we can anticipate more inventive research on blended learning that caters to evolving educational requirements and enhances the quality and accessibility of education. Blended learning not only offers students greater flexibility in their learning approaches but also presents the education community with increased prospects for enhancement and refinement to meet the progressively intricate and dynamic learning landscape.

Figure 2.2 Annual distribution of research papers related to blended learning in CNKI



The field of blended learning research in China has made significant progress, focusing on students and teachers as the main research subjects to deeply explore the impact of blended learning on educational practices and learning outcomes. As the main body of blended learning, students are required to actively participate in this education model, conduct independent learning, and improve their information literacy level. Teachers are regarded as key players in blended learning and need to play more roles in designing, implementing and managing blended learning environments to create rich teaching resources and teaching activities to support student learning.

In terms of research methods, China's blended learning research has adopted a variety of research methods to comprehensively evaluate the effectiveness of this education model. Questionnaire surveys are one of the most commonly used methods, through which information such as students' and teachers' attitudes, opinions, and satisfaction with blended learning can be obtained. Experimental research evaluates the effect of blended learning by comparing experiments and controlled experiments to further understand the impact of blended learning on student learning outcomes. The case analysis method allows researchers to deeply explore blended learning practices in different schools, subject areas, and practice situations to summarize successful experiences and potential challenges. The interview method provides the researcher with the opportunity to interact intimately with teachers and students to gain an in-depth understanding of their teaching experiences, needs, and expectations.It is worth noting that China’s blended learning research has accumulated rich research results. Zhao Dandan’s (2017) research has shown that implementing blended learning in middle school English can lead to a notable enhancement in students' engagement and academic performance.. Li Lin's (2018) Research indicates that integrating blended learning into computer courses at the college level has the potential to enhance students' independent learning and advance their information literacy skills.The work of Guo Xiaojing (2019) pointed out that in college English courses, blended learning can enhance students' interest in learning and their motivation, as well as their independent learning skills.. Liu Tao's (2018) blended learning has been found to have the potential to enhance students' learning effectiveness and satisfaction. Moreover, it underscores the significant influence of teachers in shaping course structure and administration. These results demonstrate the favorable effects of blended learning on student education and underscore the essential contribution of teachers in facilitating its implementation..In addition, China’s blended learning research also covers multiple subject areas. Wang Juan's（2018） research concentrated on high school chemistry classes and demonstrated that integrating online and traditional learning can enhance students' independent learning skills and ability to find information. The study also stressed the importance of collaboration between teachers and students.Zhao Liqun(2018) discovered that various factors, including teachers' instructional abilities, course quality, students' technical skills, and learning motivation, significantly influence students' perceptions and contentment with blended learning.. Li Jun(2017)conducted a study centered on accounting courses at the higher education level. The research revealed that integrating blended learning can enhance students' motivation to learn and their overall academic performance, though this approach demands thorough planning and oversight from instructors.Wei Zhigang et al. (2019) conducted a study on the significant influence of teachers' teaching methods and attitudes, as well as students' independent learning and active participation, on the success of blended learning. These results emphasize the need for a comprehensive consideration of instructional methods, technology utilization, student traits, and teacher-student interactions when advancing blended learning practices. Furthermore, assessing the effectiveness of blended learning is identified as a crucial aspect in Chinese research on this topic.Xie Wen (2016) examined the techniques used to assess the success of blended learning, incorporating various measures such as student academic achievement, attitude towards learning, quality of teaching and instructor satisfaction..Li Zhihua et al. (2019)employed techniques including surveys and comparisons of academic achievement to assess the impact of blended learning on college English instruction. Their findings suggested that, in comparison with conventional teaching approaches, blended learning can notably enhance students' skills in English listening, speaking, reading, writing, and overall language proficiency.

In brief, extensive progress has been made in China's blended learning research, comprising both theoretical and practical advancements. The investigation concentrated on the functions of students and educators, employed diverse study methodologies across various subject domains, and demonstrated the beneficial effects of blended learning on student interest in learning, self-directed learning capabilities, information literacy, and overall effectiveness. Nonetheless, it also emphasized the vital contribution of teachers and highlighted complex factors that necessitate further thorough exploration. Going forward, emphasis should remain on educational application in blended learning research while continually refining teaching approaches to address evolving educational requirements.

2.2.5 Challenges and problems faced in blended learning in China

Blended learning, as a modern approach to education, integrates traditional in-person teaching with online learning to enhance the effectiveness and efficiency of education. While this method has generated considerable interest in the educational realm, it encounters various challenges during practical implementation. This article will explore the primary difficulties experienced by students and educators in blended learning, address institutional issues that need resolution, and offer potential solutions to enhance the execution of blended learning.

1. Challenges faced by students:

(1). The difficulties of self-regulated learning: Blended learning demands students to possess the capacity for independent learning and effective supervision of their own learning process. Nonetheless, many students struggle with self-regulated learning. Studies indicate that insufficient motivation and poor time management skills among students can make it challenging for them to sustain a consistent approach to blended learning. This may result in confusion regarding study plans and a decrease in academic achievement(Rasheed et al., 2020).

(2). Utilizing technology effectively presents difficulties: Blended learning depends on educational technology for backing online teaching and learning endeavors. Yet, numerous students might lack familiarity or skill with the necessary technology tools and platforms. Studies have shown that students may face obstacles like technical issues, network connectivity problems, or struggles in using software, all of which can disrupt their learning process(Rasheed et al., 2020).

2. Challenges faced by teachers:

(1). Teaching with Technology: Educators should be proficient in using educational technology to facilitate both online and classroom teaching in blended learning. However, some teachers may face challenges due to insufficient knowledge and skills in educational technology. Studies have shown that educators could find it challenging to effectively integrate online and offline teaching, potentially impacting their effectiveness (Liu Fang et al., 2019).

(2). Ensuring teaching quality poses challenges: Blended learning necessitates educators to adapt instructional materials and approaches based on students' learning requirements and advancement. Nevertheless, numerous teachers may lack the necessary experience, making it challenging for them to effectively steer students in self-directed learning and practical applications. Studies indicate that there is a necessity for educators to enhance their comprehension of offering personalized assistance in blended learning in order to address diverse student needs(Li Xiaohua et al., 2020).

(3). Insufficient teaching materials: Blended learning necessitates a significant quantity of online educational materials, including online courses, virtual experiments, and instructional videos. Nevertheless, numerous educational institutions might lack the necessary resources to facilitate the adoption of blended learning. Studies indicate that educational institutions are required to allocate additional funding and resources towards creating and sustaining these instructional materials(Chen Hai et al., 2018).

In summary, blended learning has progressed to some extent in Chinese universities but still encounters various challenges. Students should enhance their self-directed learning skills, educators need to continually enhance their knowledge of educational technology and teaching effectiveness, and academic institutions must offer adequate instructional resources. By enhancing training, professional development, and resource allocation, these obstacles can be effectively tackled resulting in improved efficacy of blended learning methods and a more enriching educational experience for students. As a significant innovation in the realm of education, blended learning is anticipated to maintain its crucial role in Chinese education while adapting to evolving learning requirements.

2.2.6 Evaluation of the effectiveness of blended learning in China

The evaluation of the efficiency of blended learning in Chinese higher education institutions has consistently been a significant area of study within the field of education. Despite existing research on this topic, the overall findings remain somewhat constrained. Typically, scholars primarily assess the impact of blended learning by considering learning outcomes and student satisfaction, suggesting that it contributes positively to enhanced academic performance(Li Manli & Zhan Yisi , 2017) . Blended learning encounters practical obstacles in emphasizing the "process value" during actual teaching, primarily due to the requirement for increased time and high-quality input. This approach typically incorporates task-oriented and collaborative learning techniques, urging students to dedicate additional time to learning beyond regular class hours. However, this can result in challenges related to time management as students struggle to fully commit themselves to each course within their limited schedules.(Dziuban et al., 2018).Furthermore, issues like teacher guidance and proficiency in organizing activities, incomplete assessment methods, and students' individual learning capabilities also impact their engagement in learning. As a result, many students tend to depend more on watching instructional videos and seeking information online rather than actively engaging in discussions and sharing their perspectives. This ultimately leads to surface-level learning outcomes, posing challenges for delving into specific topics. The research also indicates that some students use hybrid teaching platforms primarily due to the insistence of teachers rather than out of genuine willingness, which further hampers student involvement.Additionally, students may exhibit limited self-regulation in online learning and lack effective supervision, potentially resulting in decreased efficiency. Furthermore, the depth and quality of communication among group members in blended learning is inadequate, leading to a lack of thorough engagement and guided reflection on course content during MOOC-based learning. To address this issue of superficial learning in blended settings, scholars have suggested various approaches such as enhancing teachers' instructional design skills, reinforcing control over blended learning environments, and establishing student support groups(Yu Shengquan & Wang Huimin, 2020) .The study also highlights the significance of assessing the efficacy of blended learning from various aspects, such as learner involvement, knowledge acquisition, social interaction, self-regulation, and emotional engagement. Consequently, evaluating learning participation has emerged as a crucial measure for gauging the success of blended learning and has garnered considerable interest among scholars.

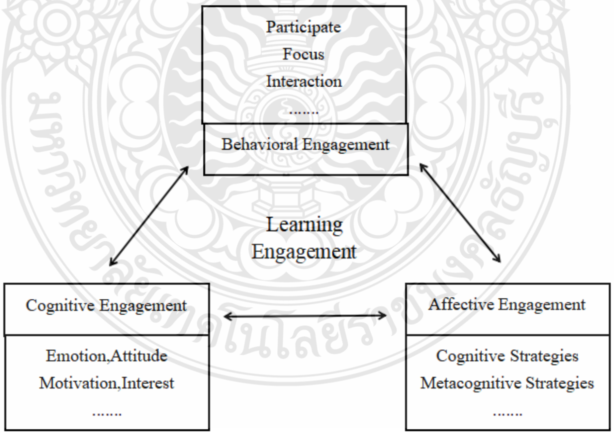
2.3 Learning to participate in research

2.3.1 The connotation and concepts of learning participation

In the 1930s, Tyler proposed the concept of "time on task" and pointed out that the more time students devote to learning, the more they learn, and the time spent on learning is positively correlated with learning gains (McCormick , AC , Kinzie , J , Gonyea , RM , 2013). This is the prototype of the concept of learning engagement. Astin (1984)argues that learning engagement encompasses both the physical and psychological commitment of learners to educational activities. They stress the importance of unifying cognitive ideologies with behavioral efforts, and combining knowledge with action. Kuh introduced the concept of "student engagement," suggesting that it is crucial for evaluating college quality from a school management perspective. Students' learning engagement comprises their personal dedication as well as institutional support, and a greater level of support from the school leads to an enhanced learning experience for students(Kuh , GD , 2001). The initial official reference to the concept of learning involvement was presented by Schaufeli(2002), who proposed that learning engagement entails learners consistently demonstrating high levels of enthusiasm and energy. This involves confronting learning tasks with perseverance and encompasses three dimensions.To confront academic challenges and persist, it is essential to categorize learning involvement into three dimensions. Fredricks(2004) proposed a framework consisting of emotional participation, behavioral participation, and cognitive participation. Emotional participation encompasses students' emotional experiences in learning activities such as interest, engagement, and self-assurance; behavioral participation involves their actions during the learning process including attendance, contribution to class discussions, and involvement in extracurricular activities; while cognitive participation pertains to their cognitive performance like actively asking questions and solving problems. Various types of engagement have distinct effects on learning outcomes with studies revealing that emotional involvement and cognitive engagement exert the most significant influence on academic achievement.GeorgeD. Kuh. (2001) expanded the definition and range of learning engagement, encompassing students' dedication to learning through both in-class and out-of-class activities as well as the institution's support for student learning efforts inside and outside the classroom.

Kahu (2013) provided a definition for learning engagement which encompasses the various behavioral, psychological, sociocultural, and holistic elements influencing a student's educational experience. The focus on studying in China leans more towards gaining knowledge from others.Kong Qiping(2000) examined the idea of learning engagement and suggested that it primarily involves dedicating time to learning and actively participating in learning activities. Wang Yashuang(2013) focused on three dimensions of learning engagement, stating that cognition includes deep learning strategies and metacognitive strategies, emotion encompasses the overall value of learning and interest in it, while behavior entails peer communication and interaction between teachers and students.According to Liao Youguo(2017) , learning engagement encompasses the degree of involvement in learning activities, students' emotional experiences, and the strategies employed for academic studies. It involves sustained enthusiasm and proactive involvement in learning, characterized primarily by vitality, dedication, and concentration. Similarly, Guo Xiao(2017) aligned with George D. Kuh(2006)’s view regarding learning engagement as encompassing student and institutional investment levels. This indicates a growing understanding of learning engagement worldwide—from an initial focus solely on students’ study time to evaluating the correlation between quantity and quality of their engagement—and from defining it as having a single dimension to recognizing it as a complex construct comprising multiple dimensions.This study elucidates the meaning of learning engagement from a psychological viewpoint. It asserts that learning engagement is an internal mental state in which learners have the capacity to independently monitor and control themselves, encompassing three aspects: behavior, emotion, and cognition as depicted in the figure below:

Figure2.3 learning engagement structure diagram



Behavioral engagement refers to a state of being highly focused, persistent, and deeply involved in the learning process. It is easily identifiable and describable. Emotional engagement indicates that learners are enthusiastic and actively participating, which can impact their behavior and cognitive processes during learning activities. Cognitive engagement involves internalizing knowledge into the learner's existing knowledge framework and is crucial for measuring the effects of learning. These forms of engagement have mutual influence on each other, potentially driven by a desire for academic success or external stimuli, leading to sustained attention, active involvement in educational activities, and application of knowledge to solve real-world problems.(Panigrahi et al., 2018)

2.3.2 Measurement research on learning engagement

The existing method of assessing student engagement in learning primarily involves capturing data through the use of scales. One such established scale is NSSE, which is designed to assess undergraduate engagement and has been developed by the Indiana University Center. This widely utilized scale serves as a means to gauge both the level and effectiveness of students' involvement in higher education, making it one of the most prevalent and commonly employed tools in higher education research(Kuh,2009).The UKES is a tool utilized for evaluating the engagement of university students. It has been developed by Kingston University in the UK and aims to measure student engagement as well as their academic, social, and personal growth experiences,the scale was launched in 2012. SERU is a widely utilized measurement tool created by the University of California, Berkeley to evaluate undergraduate students' involvement at university. It encompasses an assessment of their academic, social, and personal growth experiences and has been embraced by numerous higher education(Dziuban et al.,2018) institutions. The Online Student Engagement Scale is a tool developed by Swan et al(2010). in 2010 to evaluate the engagement of online students. It measures affective, cognitive, and behavioral engagement, as well as their attitudes and satisfaction with online learning. The scale has been extensively applied in various online learning settings. SEDE, which stands for Student Engagement in Distance Education, is a tool developed by McGill University in Canada to measure students' involvement in distance education. It evaluates cognitive, affective, and behavioral engagement among students while also taking into account their attitudes and level of satisfaction with the distance learning experience(Dziuban et al., 2018).UCUES (University of California Undergraduate Experience Survey) is a scale used to assess the engagement of undergraduates at the University of California, compiled by the University of California. This scale is designed to assess students' experiences in academic, social and personal development, as well as their attitudes and satisfaction with university life. This scale has been widely adopted by the University of California system. CSEQ (College Student Experiences Questionnaire) is a scale used to assess the engagement of university undergraduates, developed by the University of Western Ontario, Canada. The scale is designed to assess student engagement and learning experiences, including academic, social and personal development. Several higher education institutions have implemented this scale. The UWES-S was created based on the UWES work engagement scale.Schaufeli(2006)suggests that specialized scales are necessary for measuring input. Drawing from the job burnout scale developed by Maslach and Jackson in 1981, she proposes that the work engagement scale should encompass three dimensions: vigor, concentration, absorption, and dedication.Vigor signifies the period of encountering education. It involves maintaining high energy and persisting in adversity. Concentration entails wholehearted commitment to learning, experiencing time passing swiftly, and being unwilling to disengage from learning. Dedication involves an awareness of the significance and challenges inherent in the process of learning.Once the scale became public, it gained significant recognition domestically and internationally, emerging as the primary instrument for assessing learning involvement during that period. Subsequently, this scale has been implemented in numerous higher education establishments across multiple nations(Schaufeli et al., 2012). The HSSSE is a tool utilized to evaluate the level of involvement and participation among high school students. Developed by the Indiana University Center in the United States, it aims to gauge students' interactions within academic, social, and personal domains, as well as their overall outlook on and contentment with high school experiences. Multiple high schools have implemented this assessment tool.(Назаренко, 2014).The Classroom Engagement Inventory is a tool utilized to evaluate the level of engagement among elementary and high school pupils. Developed by the University of California, Los Angeles, this instrument aims to gauge students' involvement in classroom activities as well as their overall learning experiences encompassing academic, social, and personal growth. It has been implemented by various educational establishments.(Wei et al., 2017). As shown in Table 2.1, the current excellent learning engagement measurement scales are sorted out:

Table 2.1 Statistics of currently more mature learning engagement measurement scales

No.	Measurement table name	Author or institution/time	Measurement object	Measurement dimensions
1	NSSE (National Survey of Student Engagement)	Indiana University Center for Postsecondary Research/2000	Undergraduate	teacher-student interaction , educational experience, challenges faced by students The level of cooperation among students, the level of cooperative learning among students, and the support of the school’s campus environment
2	UKES (The University of Kingston Engagement Survey)	The University of Kingston/ 2001	Undergraduate	Academic knowledge, academic skills, cognition and metacognition, professional skills, personal and professional

				development, social and civic engagement
3	SERU (Student Experience in the Research University)	SERU Alliance (2004)	Undergraduate	Academic experience, student life, social and cultural experience, satisfaction and career plans
4	OSES (Online Student Engagement Scale)	Dixson , M. D. / 2010	Undergraduate	Social engagement, course engagement, cognitive engagement, emotional engagement
5	SEDE (Student Engagement in Distance Education)	Karen Swan/2001	distance learning students	Cognitive engagement/emotional engagement, behavioral engagement
6	UCUES (University of California Undergraduate Experience Survey)	University of California, Los Angeles/2001	Undergraduate	Curriculum, Tutors, Research, Student Life, Community Involvement, Educational Goals
7	CSEQ (College Student Experiences Questionnaire)	Pace, C. R/1991	Undergraduate	Academic experience, social experience, personal development experience
8	UWES-S (Utrecht Work Engagement Scale-Student)	Schaufeli, W.B., Bakker, AB, & Salanova, M. /2012	Undergraduate	Enthusiasm, commitment, focus
9	HSSSE (High School Survey of Student Engagement)	Fleener, J./2004	High school student	Learning engagement, behavioral engagement, emotional engagement

10	FCEI (Classroom Engagement Inventory)	Fredricks/ 2004	primary school student	Cognitive engagement, emotional engagement, behavioral engagement

Research on student engagement in China typically relies on established international surveys to outline the traits of Chinese students and create questionnaires and scales tailored to local students.Tsinghua University conducted specific research and made adaptations to NSSE in line with the country's unique circumstancescreated NSSE-CHINA, a Chinese adaptation of the original NSSE questionnaire, with preserved item indicators and demonstrated reliability and validity.Fang Laitan and Shi Kan (2008) conducted an assessment of the UWES-S scale in a Chinese context, demonstrating its high reliability and validity. This suggests that the Chinese version of the UWES-S scale is suitable for assessing talents in domestic higher education, with a focus on evaluating mental well-being.The essence of the evaluation centers on determining the thoroughness of the individual's mental condition. Li Xiying & Huang Rong (2010) made refinements to the UWES-S scale for a second time, introducing a new dimension. Subsequently, numerous scholars enhanced this foundation and implemented it following the development of two specific questionnaires.Many research studies have examined the various dimensions of learning engagement, and these differ based on different perspectives. Chinese measurement scales are largely developed from existing foreign scales. This study adapts a research framework for assessing learning engagement among Chinese college students by incorporating their unique characteristics while also drawing upon established foreign scales to address specific research requirements.

2.3.3 The concept of engagement in blended learning

The conceptual and structural dimensions of learning engagement have long been important issues in learning research. Domestic and foreign researchers have conducted in-depth discussions on learning engagement, and different scholars have proposed different perspectives and dimensions to understand learning engagement. With the continuous development of learning theory and the popularization of Internet technology, the connotation and structure of learning engagement are also constantly evolving. In traditional learning theory, learning engagement mainly focuses on the cognitive and emotional involvement of individual learners. For example, Fredricks et al. (2004) proposed a three-dimensional structure of learning engagement, including behavioral engagement, emotional engagement and cognitive engagement. This structure emphasizes the learner's behavioral performance, emotional experience and thinking activities during the learning process. This classic three-dimensional structure has been widely used in learning research. However, in the Internet age, the forms and methods of learning have undergone tremendous changes. Learning is no longer limited to traditional classrooms and textbooks, learners can learn through online learning platforms, social media and multimedia resources. Therefore, the understanding of learning engagement also needs to be more diversified and comprehensive. Reeve (2012) added the dimension of “active investment” on this basis, emphasizing the active role of learners in creating a supportive learning environment. In a blended learning environment, learners need to show different forms of learning engagement in different learning situations. They may need to learn course content online, participate in offline practical activities, interact with classmates and teachers online, and use various educational technology tools and platforms. This diversified learning requires learners to demonstrate multiple dimensions of learning engagement such as behavioral engagement, emotional engagement, Cognitive engagement and social interaction investment in different situations. In general, the understanding of learning engagement is no longer limited to traditional cognitive and emotional engagement, but includes more diverse dimensions. This more comprehensive and diversified understanding helps us better understand learners' learning processes in blended learning environments, and provides a richer reference for educational practice and instructional design. In the future, with the continuous development and evolution of blended learning, research on learning engagement will continue to expand its theoretical framework to adapt to changing learning needs and technological innovation. This will provide more opportunities for improvement and optimization in the education sector to increase the quality and accessibility of learning.

2.3.4 Current status of research on blended learning engagement

The rise of blended learning and the growing focus on engaging students in the learning process has prompted experts and scholars to explore research on this topic. However, there is a limited number of studies from a literature standpoint, with most focusing on more recent time periods.Zhou Yuan (2018) et al. conducted research on the impact of various elements, including homework, tests, and in-person instruction by teachers, on learners' engagement with blended learning activities. Their findings offer valuable insights for educators seeking to enhance students' participation in real-world educational settings.Scholars like Wu Yan have enhanced and applied the hybrid learning approach, examined student feedback and its influential elements, and put forward viable instructional methods to offer direction for integrating the blended learning model and enhancing teaching approaches. In a study by Ma Jing and Zhou Qian(2020), it was discovered through the use of questionnaires and empirical research techniques that teaching practices have a notably positive influence on learners' levels of engagement, particularly with regard to the design and organization of instructional activities.It is advised for educators to plan and structure their teaching in a thoughtful manner. Implementing successful teaching practices during the organization of instruction offers both theoretical and practical guidance for teachers when designing and organizing blended learning experiences.Xie Guangdao 's (2020) conducted research on a blended teaching approach for English classes that focused on promoting student engagement. The study revealed improved performance in learning tasks involving teacher guidance, leading to the recommendation of customizing and refining learning materials while also making activities more captivating to boost students' participation and interest in English courses.Li Junyan(2020) conducted a study on instructional design theory and discovered that the hybrid collaborative learning approach significantly enhanced student engagement and offered educators a structured design process. Similarly, Zhao

Chun(2020)and fellow researchers introduced a framework for assessing blended learning engagement from an activity theory perspective, outlining the components of analysis and outcomes in blended learning engagement, thus presenting fresh insights for diagnosing and optimizing strategies within blended learning programs.Zhu Zhendi and Li Hongbo (2019)conducted a study on blended learning practices for specific courses, examining the learning engagement of secondary vocational students. This research aims to serve as a foundation for enhancing student engagement in this context. Their work involved using various methods such as developing blended learning models, practical teaching, and questionnaire surveys. Scholars have approached the topic of learners' engagement in blended learning from different angles, offering both theoretical and practical perspectives. Building upon related research on blended learning and learner engagement, this study delves into evaluating the composition of learners' engagement specifically within the context of blended learning to provide more comprehensive theoretical support in this field.

2.3.5 engagement in blended learning in Chinese universities

The increasing adoption of blended learning and the growing recognition of the significance of learner engagement have led researchers to investigate this area more actively. However, there remains a relatively limited number of academic studies on learning engagement in blended learning, with a majority being conducted in recent years.Scholars like Zhou Yuan(2015) have examined three distinct blended learning activities to gain insight into the engagement of learners. Their analysis revealed that elements such as homework, assessments, and in-person teaching by instructors can enhance the engagement of learners, offering valuable insights for educators seeking to enhance student engagement in real-world instructional settings.The researchers examined learners' engagement and influencing factors in the blended learning model, and suggested effective teaching strategies through practical experience gained from implementing and refining this approach.(Wu Yan. , 2019).Ma Jing & Zhou Qian(2017) conducted survey research and empirical studies to demonstrate that teaching behavior plays a crucial role in influencing learners' engagement with their learning. They found that well-organized teaching has the most significant impact, indicating the importance of implementing effective teaching behaviors during instructional design to enhance students' engagement.Xie Guangda(2018)'s study on the blended learning approach for English courses focused on student engagement and concluded that students demonstrated improved involvement in learning activities when guided by instructors. As a result, he suggested customizing and refining course content to enhance student engagement in English classes.Li Junyan(2019)'s research delved into the realm of instructional design theory, examining how the hybrid collaborative learning model influences student engagement. The findings revealed that this approach significantly enhances students' level of involvement in learning activities, while also offering educators valuable insights and recommendations for designing effective teaching strategies.Scholars like Zhao Chun(2020) have put forward a framework for researching blended learning engagement. Drawing on activity theory, they have outlined the analysis and factors that influence blended learning engagement, offering fresh insights for diagnosing and optimizing blended learning courses.Zhu Zhendi & Li Hongbo(2019 implemented a blended learning approach to teach specific courses, conducting an assessment and analysis of the involvement of secondary vocational students. Their findings serve as a foundation for enhancing the participation of these students in their studies.Researchers have utilized diverse approaches to investigate learning engagement in blended learning, including creating blended learning activities, carrying out practical exercises, and assessing learners' engagement using surveys and other techniques. These investigations not only advance the advancement of blended learning overall but also offer educators tangible recommendations for enhancing student involvement in education. Moving forward, factors influencing learners' engagement in blended learning could be further examined by leveraging online learning platforms and interactive resources.

2.4 Research on evaluation indicators of learning engagement

The examination of assessment factors for learning engagement is a critical research area in the field of education. It is important to grasp how students participate and involve themselves in the educational process in order to enhance academic results. Active participation in learning can greatly influence students' meaningful acquisition of knowledge.(Henrie et al., 2015).Research encompasses various facets, such as learning motivation, behavior, and outcomes. Regarding motivation, scholars have examined both intrinsic and extrinsic factors driving students' engagement. In terms of behavior, studies center on student involvement in the learning process, utilization of strategies, and active participation in courses or training.(Heilporn et al., 2021) Additionally, it is important to consider the correlation between student involvement and academic achievement when discussing learning outcomes. Researchers have utilized a range of techniques such as questionnaires, observations, interviews, and data analysis to gather information on student engagement. Statistical analysis tools are then employed to establish applicable metrics and models. These metrics and models hold value not only in scholarly inquiry but also offer practical insights for shaping educational policies and enhancing the overall learning experience and outcomes for students.(Anthony et al., 2020).Researching indicators for evaluating learning engagement is essential for comprehending the level of individual involvement in the educational process. It not only supports detailed academic discussions but also offers effective tools and techniques to enhance education. This research helps us gain a deeper understanding of learners' requirements and motivations, enabling us to address their learning needs more effectively.

2.4.1 Behavioral engagement

Behavioral engagement research, rooted in the Task Time Theory proposed by Tyler in the 1930s, is a crucial field within learning engagement studies. This research focuses on students' behavioral performance during learning activities, including factors such as time invested, intensity of activity, and level of effort exerted(Jacob et al., 1987; Patrick et al., 1993),such as attending class on time, listening carefully, actively answering teacher's questions, submitting homework on time, not giving up in the face of difficulties, etc. Finn (1989) defined behavioral engagement as students Participation in school academic and extracurricular activities. Skinner(1993) defines behavioral engagement as the level of involvement exhibited by students in learning tasks, whereas Miserandino(1996) suggests that behavioral engagement relates to the visible classroom behaviors demonstrated by students.According to Marks(1998), behavioral engagement encompasses not only the effort students put into class activities, but also their involvement in extracurricular pursuits. In essence, it pertains to the time that students dedicate to learning activities, with energy and effort being noticeable outward behaviors.Behavioral engagement pertains to the level of effort exerted by students in educational tasks and their active involvement in learning activities(Wang, H. et al., 2019). Participation involves the commitment of time and effort by students in fundamental course activities. In research on behavioral engagement in learning, three crucial aspects have been recognized: participation, concentration, and persistence. These facets represent the dedication of students to their learning tasks, their capacity to maintain focus, and their resilience and determination when faced with obstacles.These measurements are crucial for gauging behavioral involvement and can be utilized to evaluate the extent of student participation in the educational journey.Finn(1989) and Fredricks (2004) explore this type of engagement. Birch, Ladd, and other researchers emphasize the initial form of behavior in which students adhere to curriculum guidelines and meet teacher expectations.Birch & Ladd (1997) describe it as behavior that conforms to teacher expectations. Some studies define engagement in prescribed activities linked to course assessment as performance commitment, including punctual submission of assignments, fulfillment of tasks, and adherence to exam timetables(Handelsman et al., 2005). Compared to alternative investment types, participation-based investing displays less connection with deep learning. However, it plays a significant role in student engagement within courses by demonstrating their recognition of course regulations and expectations, which sets the stage for further behavioral involvement. Several experts consider "persistence" and "focus" as signs of students' understanding of course rules and expectations, along with their commitment to putting in effort(Patrick et al.,1993). Students' ability to persist involves their reactions and achievement when encountering obstacles or difficulties. It indicates their resolve to persevere and actively look for solutions. Persistence can also indicate continual involvement in learning activities, demonstrating students' readiness to surpass basic expectations and dedicate extra effort. These actions display students' dedication to reaching their educational objectives and their drive for success. Concentration relates to the level of exertion a student puts forth in maintaining focus. "Focused" students are able to remain attentive amid external distractions, as seen through active listening, task prioritization, losing track of time, etc. Concentration reflects students' inherent interest in the learning material and their capacity to resist outside disruptions. Essentially,"persistence" and "concentration" behaviors reflect how well students manage effort and align with the application of metacognitive strategies(Meece et al., 1988; Miller et al., 1996).

2.4.2 Cognitive engagement

Cognitive involvement mainly appears in how students absorb knowledge and apply learning methods. The primary indicators used to measure cognitive engagement in current studies can be divided into two groups: the first focuses on mastering knowledge, while the second aims to improve cognition and critical thinking skills, including logical and creative thinking. Therefore, both categories are suitable for assessing cognitive engagement. According to the definition of cognitive involvement, students have the freedom to choose from various learning strategies in different educational settings. Some research suggests that students typically evaluate cognitive engagement through measurement items such as cognitive strategies, metacognitive strategies, self-monitoring, and time management. Moreover,,some scholars use self-regulation-related items as a measure of cognitive involvement(Fredricks, 2004). The Motivated Strategies for Learning Questionnaire, created by Pintrich(1991) and other researchers, is commonly used as a benchmark for assessing cognitive engagement. The cognitive strategies and self-regulation subscales in the MSLQ are especially significant. The cognitive strategies subscale includes elaboration strategies and the use of organizational strategies, with elaboration strategies designed to help learners integrate new knowledge, form internal connections, and connect new information with prior knowledge.Organizational approaches aim to create links between new information and help learners in choosing pertinent material, involving them actively in tasks. The self-regulation aspect centers on the overall process of metacognitive self-regulation activities, encompassing goal setting, activity planning, and monitoring and regulating cognitive activities to enhance effective completion of learning tasks. Some scholars have modified the cognitive engagement scale put forward by researchers such as Miller(1996) to gauge students' involvement in academic pursuits across five dimensions: self-regulation,,usage of profound and superficial cognitive strategies, perseverance,,and exertion. While there are subtle disparities among research projects compiled by various scholars, there are clear resemblances in the definition of cognitive engagement and the process for developing the scale.The MSLQ scale includes items on strategy use that reflect both deep and surface-level cognitive processes, which are directly linked to measuring cognitive engagement through the depth of knowledge processing and self-regulation theory(Greene, 2015).

2.4.3 Emotional engagement

Emotional involvement relates to the interest, perceived significance, and emotional encounters throughout educational tasks(Wang Hongmei et al., 2019). Assessments of emotional involvement often consider elements such as students' enthusiasm for learning activities, their feeling of social belonging with classmates, and their individual emotional responses. These affective reactions are usually assessed in terms of two facets: positive emotions and negative emotions.For instance, Wellborn (1992) created a school assessment tool for Rochester as a component of his doctoral dissertation on "Engagement and Dissatisfaction Behavior: Conceptualization and Measurement of Motivation in Academic Fields." This tool included emotional markers such as joy, annoyance, anger, boredom, and irritability.Similarly, Watson assembled 10 items for both positive and negative emotion dimensions. Several of these items were selected from college students and produced positive results. Some of these items are used as standards by other researchers when evaluating emotional involvement, including elements such as eagerness, thrill, concentration, energy, unease, worry, discomfort,, stress levels discontentment and more. Additionally,research explores value-related factors like the importance of learning and self-worth.(Wang & Degol, 2014)The measurement method for emotional engagement in diverse learning environments aligns with the approach used for other levels of engagement. In terms of assessment criteria, it focuses on exploring students' interest in tasks and their different emotional reactions. Using student self-report methods offers a comprehensive way to assess students' engagement across behavioral, cognitive, and affective domains while also being economical.Teachers have the opportunity to improve course design using the data obtained from student learning. However, relying solely on self-reported methods by students has limitations due to potential subjective bias, as studies have shown disparities between these reports and actual observational data(Greene BA, 2015). Furthermore, the dynamic nature of students' learning engagement means that it can fluctuate over time, particularly in terms of behavioral and emotional involvement. To address this challenge, certain studies recommend using experience sampling methods to assess fluctuations in students' levels of learning engagement at various points in time(Hektner JM et al., 2007).Experience sampling is a method for collecting longitudinal data in real educational environments, capturing information about the activities, emotions, and situational context of individuals(Manwaring KC et al., 2017). Research results demonstrate its effectiveness in capturing the fluidity of emotional involvement data and examining the immediate simultaneous occurrence of students' emotions within academic environments(Moeller J et al., 2018). Additionally, research employs experience sampling methods to collect information on students' everyday occurrences in hybrid learning settings(Manwaring KC, 2017). Currently, academic studies on emotional engagement mainly utilize methods based on questionnaires for data collection, where learners assess their emotions. The key metrics used for measurement are outlined in the table below. Emotional engagement is commonly evaluated by directly asking about emotional experiences or through analyzing written expressions, with a focus on students' emotions as an important measure of engagement(Günüç & Kuzu, 2014).

2.5 Delphi Technique

This review addresses three key domains concerning the Delphi technique and its utilization within an instructional design framework, as follows:

2.5.1 Definition of The Delphi Technique

The Delphi technique is a methodology that utilizes written questionnaires to mitigate personal biases and the impact of dominant personalities. It employs a structured questionnaire system comprising multiple rounds of inquiries distributed to a panel of experts. These experts offer anonymous responses in each round and have the opportunity to refine their answers in subsequent rounds. The process yields diverse res`ponses, with the consensus from each round shared among all panel members, culminating in a definitive "correct" response (Rowe & Wright, 1999). This technique is often characterized as a facilitator of group communication for addressing intricate issues involving a collective of individuals (Linstone & Turoff, 1975).The Delphi Technique is a research method that facilitates gathering insights and opinions from a panel of experts in order to reach consensus or make informed decisions. The technique involves multiple rounds of questionnaires or interviews, allowing experts to provide feedback and revise their opinions based on the group's input(Yusuf, 2007).Inaugurated in 1953, the Delphi technique emerged initially to solicit insights from military officers regarding wartime ordnance requirements. Over time, it has become a prevalent method for preparing for diverse challenging scenarios that may unfold in the future. This technique entails iterative rounds of questionnaires dispersed among a chosen cohort of distinguished professionals renowned for their expertise in specific domains. Responses garnered from each round inform the formulation of subsequent questions, ultimately culminating in the establishment of a consensus. (Witkin & Auschuld, 1995).

2.5.2 The Delphi Method and Analyzing Decisions

The Delphi method depends on the scrutiny of expert viewpoints and reaching agreement among them, all guided by formal procedures for collecting and analyzing data. Consensus-building is a crucial element of the Delphi method. According to Gordon(1994) and Turoff (2002), the Delphi technique is a strategy created to facilitate effective group communication, enabling a collective of individuals to address complex problems as a unified entity. Gordon(1994) defines it as a structured debate and an influential tool for addressing relevant questions. Pollard and Pollard propose that the questionnaire system utilized in the Delphi method allows experts to comprehensively assess and deliberate on every aspect of a given problem. In the initial round of questionnaires, using open-ended questions with narrative components helps extract extensive knowledge accumulated by these experts over many years.Both the Delphi method and nominal group consensus approaches follow formal protocols for gathering and analyzing expert opinions, with consensus-building techniques being vital elements in both methods.

Table 2.2 The strengths and limitation of the Delphi technique

Advantages of the Delphi method(Fink et al., 1984,)	**The drawbacks of the Delphi technique**(Sangsawang, T. 2020)
- A group of specialists is chosen to offer expertise and come to an agreement.	-The response quality is contingent on the panel's performance
-This formal consensus approach has become ingrained in the process for addressing issues	-Researchers should carefully select their participants.

-The consensus approach helps gather and assess the information offered by experts.	-Interactions between researchers and participants do not occur in person.

2.5.3 Definition of The Delphi Technique

The Delphi method uses written surveys to minimize the impact of individual biases and strong personalities. It includes a systematic questionnaire system with multiple survey rounds sent to a panel of experts. After each round, the anonymous responses are gathered and shared with the group, allowing experts to adjust their answers in subsequent rounds. By conducting several question rounds and sharing collective insights, the Delphi method aims to reach an agreed-upon answer through consensus.(Rowe & Wright, 1999). According to Linstone and Turoff (1975) , the Delphi technique is a method for organizing group communication in order to facilitate collaboration among individuals in solving intricate problems.The Delphi method provides researchers with clear benefits compared to conventional survey research and relies on key elements such as efficient communication, a panel of specialists, and useful input. This paper establishes the foundation for comprehending the Delphi technique, examines its advantages and limitations, explains its stages and application, explores expert panel selection, and describes the process of reaching consensus among participants.(Yusuf, 2007).The Delphi method was first created in 1953 to gather the opinions of military officers on wartime ordnance needs. Since then, it has been modified to tackle diverse and forward-looking inquiries. This recurring process involves sending out multiple sets of surveys to a select group of recognized experts in a particular field. The responses from each round guide the development of the next set of questions, aiming to achieve consensus, disagreement, and additional insights. The Delphi technique can be customized for face-to-face meetings or online platforms.(Witkin & Auschuld, 1995).The Delphi technique involves using a group of knowledgeable individuals to provide predictions, make choices, and address intricate issues (Skagfeld & Derbyshire, 2011).In brief, the Delphi method utilizes anonymous participation and ongoing discussions among experts to reach consensus, making it a fundamental aspect of this technique.

2.5.4 The Use of the Delphi Technique

The Delphi technique is widely acknowledged by experts for its wide array of uses and there are various perspectives on it. (Linstone & Turoff, 2002). Some notable examples include:

1. Compiling current and historical data in situations where precise information is not readily accessible.
2. Examining past occurrences and their consequences.
3. Carrying out studies to determine the practicality of budget allocations.
4. Assessing the viability of urban and regional planning endeavors.
5. Creating customized educational curricula to meet specific requirements.
6. Assessing the advantages and disadvantages of potential policy choices.

7. Recognizing and enhancing comprehension of cause-effect relationships within intricate economic or social phenomena.
8. Revealing both real and perceived personal motivations.

The adaptability of the Delphi technique renders it a valuable instrument for tackling a wide range of complex issues across diverse fields."

2.5.5 Frameworks for the Altered Delphi Method in Educational Design

The Delphi technique was developed to facilitate the collection of input from participants without necessitating in-person interactions. It is commonly employed to establish agreement among experts with diverse perspectives, fostering collaborative problem-solving through a structured procedure that encompasses defining the issue, deliberations, feedback, and iterative adjustments. The adapted form of the Delphi technique outlined here utilizes postal mail or electronic mail for information gathering, providing feedback, and conveying final conclusions.The preliminary groundwork for initiating the Delphi process involves tasks executed by the planning committee or sponsor. They are accountable for defining the problem under discussion and appointing a communications manager responsible for sending messages, collecting responses,and summarizing findings. Additional responsibilities include developing or reviewing an initial questionnaire that will be distributed to participants.

2.5.5.1 Round One : In the first phase of the Delphi technique, the survey tool plays a critical role in defining the issue being evaluated. Each participant is responsible for generating numerous responses, ideas, solutions, or approaches relevant to the topic at hand. The process of collecting these responses differs depending on whether the survey is conducted through traditional mail or email. In mail surveys, participants receive a questionnaire with spaces to write down their thoughts and ideas; meanwhile, email-based surveys are structured to encourage input by using the "reply" function. For instance, participants could be asked "What methods can our committee use to increase downtown retail sales? Please provide as many ideas as you can using brief phrases or single words." They might also be prompted to suggest themes for an upcoming festival using concise phrases or words. It's important to highlight that participants contribute anonymously in order to promote open and impartial input. Following this initial stage, the next step involves compiling all responses. The communication manager is responsible for gathering and organizing ideas and solutions provided by participants. Subsequently they create a follow-up questionnaire aimed at obtaining feedback on each idea and solution shared in earlier rounds(Ouimet et al., 2004).

2.5.5.2 Round Two: In the second phase of the Delphi technique, the survey includes all responses gathered from the initial round. Participants are required to assess each idea, providing clarity or additional insights and evaluating their feasibility. They are also urged to generate new strategies and suggest completely fresh ideas. It is important to note that participants maintain anonymity while giving feedback at this stage. Following completion of the second round, the subsequent step involves consolidating the responses. The communications manager plays a crucial role in expanding on the list of ideas with comments, additions, clarifications, and strategies contributed by participants. Using this consolidated information, they then create a third questionnaire by incorporating valuable input obtained during the second round(Christodoulou et al., 2008).

2.5.5.3 Round Three: During the third phase of the Delphi technique, the communications manager maintains the process of gathering information, sharing it with participants, and seeking their feedback. In this stage, the third survey might ask respondents to prioritize ideas using different criteria such as importance, timeliness, or their willingness to actively engage in a specific project. Round Three marks the final step in collecting feedback unless further rounds are considered necessary by the planning committee. At this point, participants typically identify and prioritize practical ideas. As a result, the communications manager presents these ideas or strategies along with implementation details that align with the group's established priorities. This stage involves concluding and documenting the process while focusing on sorting out promising ideas based on consensus reached by contributors.(Hilliard, 2002).

2.5.5.4 Round Four: In the fourth phase of the Delphi study, the communications manager continues to work closely with participants to further improve and validate promising ideas and strategies. At this stage, in-depth discussions and analyses may be introduced to address unclear issues or those that are under debate. Participants might be requested to offer more specific suggestions and plans for putting the identified priorities into action effectively. Furthermore, in this phase, there could be refinement and enhancement of previously proposed ideas and strategies to tackle potential problems or challenges. As before, participant anonymity is maintained to ensure unbiased discussions. The main goal remains confirming the most promising ideas and strategies ultimately. Through this round of collaboration and feedback, the team can better prepare for implementation while providing targeted guidance for future plans.(Sense, 2007).

CHAPTER 3
METHODOLOGY

3.1 Research Perspective

The research of objectives of the study are as follows(1) Synthesize the evaluation elements of blended learning engagement in Chinese universities (2) Construct the evaluation system of blended learning engagement in Chinese universities and apply to Chinese universities.This study describes the research methodology used in the Delph technique to collect data. The research used quantitative, qualitative, and analytic hierarchy process(AHP)methods. In order to verify the effectiveness of the evaluation system, this study is practiced in Sichuan Light and Chemical Engineering University, and the fuzzy comprehensive evaluation method is adopted to evaluate the blended learning input of college students.The research instruments for data collection, the data collection procedures, and the statistical methods used for data analysis are explained as follows:

3.2 PhaseI: To synthesize the Various indicators of the Blended Learning Engagement Evaluation System

3.2.1 Participants

In the four research rounds and weight determination, 17 experts from Chinese universities were involved. Each expert was chosen through a selective sampling process. These experts are knowledgeable in higher education and educational technology, holding a doctorate or at least an associate professor's degree with over five years of experience, including serving as an assistant professor. Invitations were extended individually to each participant following Ludwig's belief that the quality of participants is more significant than the quantity . The collected data was analyzed using inductive methods for interpretation, as illustrated in Appendix A (Bryman, 2012) and diverse sampling methods(Cohen et al., 2011) were used to select participants. According to Creswell & Clark (2011,) , Purposive sampling allows for in-depth exploration and comprehension of the main theme or issue that the researcher wants to investigate. With this strategy, participants are chosen specifically because they can provide valuable insights into the central phenomenon being studied(Creswell , 2009) . Patton (2002) suggests that rather than gathering standardized data from a large and statistically significant sample, it is more effective to concentrate on a few specifically chosen participants. This approach was considered suitable for this study as the researchers selected individuals with expertise in blended learning and research related to learning, who possessed adequate knowledge and experience(Creswell & Clark, 2011; Gilbert & Stoneman, 2016).

3. 2.2 Instrumentation

Semi-structured interviews: In the first stage of the research, a semi-structured interview approach was employed. This method involves asking questions within a predefined thematic framework. It allows for flexibility in question order and wording, enabling modifications to the interview guide over time to concentrate on topics that are especially significant and pertinent to participants' perspectives and attitudes aligned with the study's objectives(Denscombe, 2007).The primary aim of utilizing semi-structured interviews in this research is to obtain a comprehensive insight into the perspectives, opinions, and recommendations of participants regarding the assessment process for blended learning involvement.According to Matthews & Ross (2010), A well-defined and adaptable set of interview queries is valuable for achieving a deeper comprehension or fostering an organic and illuminating discussion. The researcher carried out two kinds of interviews: phone interviews and in-person interviews.Telephone interviews are employed in situations where participants are spread out over different locations and cannot physically attend an interview at a specific central site. This method involves researchers interacting with respondents through telephone conversations using predetermined questionnaires for data collection. In the current research, due to the geographical separation between the interviewer and interviewees, both telephone and face-to-face interviews were utilized.Creswell (2012) defines telephone interviews as a method of collecting data through phone conversations, involving asking concise and targeted general questions to gather information. For the research, researchers utilized recording software on their phones to ensure comprehensive coverage of the interviews. In total, 17 participants were interviewed either in person or via telephone.Face-to-face interviews are widely used in educational research as a method of collecting data. Researchers directly communicate with participants using prepared questionnaires to ensure the quality of the information obtained. This involves asking questions to each participant individually and recording their answers(Denscombe, 2007). In this study, a total of 17 participants took this format. Semi-structured interviews are characterized by a focus on obtaining expert opinions on each idea through questioning. This is discussed below:

A.The concept of building a blended learning engagement evaluation system?

B.What principles should the blended learning learning engagement evaluation system follow?

C.What main dimensions do you think should be included in the blended learning engagement indicator system?

D.What key factors do you think should be considered when determining investment indicators for blended learning?Indicator ?

E. How does differentiate between investment in online learning and traditional face-to-face learning?

F.How does account for differences across disciplines and courses?

G.How does ensure the reliability and validity of the evaluation system?

Questionnaire I : Questionnaire I assesses the perspectives of experts regarding the assessment system for blended learning engagement in higher education institutions. The construction of this questionnaire was informed by data from semi-structured interviews to ensure the validity of its content. It involved 17 experts tasked with evaluating four aspects of learning engagement: behavioral, emotional, cognitive, and social engagement. The evaluation used a five-point Likert scale (Likert, 1932; Verhagen et al., 1998; Linacre, 2002), where 1 means "strongly disagree", 2 means "disagree", 3 means "neutral", and 4 means " Moderately agree” and 5 means “strongly agree”.

Questionnaire II : Based on the outcomes of the expert discussion, we amalgamated the viewpoints and crafted corresponding responses. These replies were categorized into commonalities and discrepancies to incorporate experts' input, resulting in Questionnaire

II for the third phase. Questionnaire II used a five-point Likert scale (Likert, 1932; Verhagen et al., 1998; Linacre, 2002), where 1 means "strongly disagree", 2 means "disagree", 3 means "neutral", 4 means "moderately agree" and 5 means "strongly agree".
Questionnaire III: 17 experts participated in the survey, where they analyzed, categorized, and synthesized the responses to identify common themes and provide recommendations. They utilized "yes," "no," and "not sure" responses to assess the content validity of the evaluation system framework for blended learning engagement. Ultimately, they established the evaluation system framework based on their findings.
Questionnaire IV: A group of 17 experts performed pairwise assessments and evaluated the significance of the assessment criteria. Subsequently, the scores provided by these 17 experts for each comparison were averaged to create the ultimate comparison matrix. The weight calculation formula was then utilized with this matrix to determine the weight of each evaluation criterion and establish the complete evaluation index system. This approach aids in determining the relative importance of each indicator within the evaluation system, leading to a more precise assessment of engagement in blended learning.

3.2.3 Delphi method

Round 1: In the brainstorming session, the researcher focused on the definition of blended learning engagement indicators, indicator factors , indicator validity, etc. , and used the analysis results in the framework of semi-structured interviews. Questionnaires were sent to a panel of 17 experts, who had two to two and a half weeks to complete and return the first round of questions. After receiving the responses, the answers were categorized, synthesized and developed into another questionnaire (Questionnaire I).
Round 2 : This is the stage of evaluation of expert opinions where a five-point Likert scale is used to evaluate expert feedback (Likert, 1932). In the second round of evaluation, Questionnaire I was used to determine indicators of various dimensions of blended learning engagement, and then the comprehensive results were used to formulate Questionnaire II, which used a five-point Likert scale and was distributed to the third round of expert.
Round 3: In this re-evaluation stage, the items selected from the results of Questionnaire II include first-level indicators, second-level indicators and third-level indicators. Similarities meant that most of the 17 experts agreed, while differences meant they disagreed on some aspects. This ensures the scientific nature of the constructed indicator system. These comprehensive results will be used to develop Questionnaire III.
Round 4: In the final round of evaluation, feasible ideas have been identified and the model framework confirmed by conducting the questionnaire again. This process will help ensure that the final model framework is determined based on expert opinion to provide a scientific basis for the assessment of engagement in blended learning.

3.2.4 AHP analytic hierarchy process

The AHP method decomposes the decision-making problem into multiple layers, thus forming a hierarchical structure with a one-way hierarchical relationship between each layer. AHP has the advantage of combining qualitative analysis with quantitative analysis, providing a new, simple and practical basis for building an evaluation system for blended learning engagement in colleges and universities . In AHP, the weight of an attribute is calculated by comparing the relative importance of two factors. Furthermore, the calculated priorities are appropriate only if the pairwise comparison matrix passes the consistency test . The obvious advantage of using AHP is that it combines qualitative and quantitative criteria to obtain a single score and forms a hierarchical decision-making structure (Ishizaka, A., & Lusti, M. , 2010).

3.2.5 Data collection

Data were collected using the Delphi technique. Data collection is divided into four rounds:

Round 1: Brainstorming

The first round is to brainstorm experts through semi-structured questionnaires on the blended learning engagement evaluation system . All these questionnaires focus on indicator elements and learning engagement dimensions to form a preliminary framework. The first round of data collection process is as follows:

1. The researchers reached out to 17 knowledgeable experts via phone and invited them to participate in the study through the utilization of the Delphi technique.
2. After receiving approval from all 17 proficient professionals, the researcher formally sent out an invitation letter.
3. The researcher scheduled meetings with all eligible experts for the requested dates and times.
4. 10 experts agreed to participate in a face-to-face session with the researcher and were given a survey during the meeting. Three specialists offered feedback on the survey during these meetings, which the researcher documented, while seven provided their input through face-to-face discussions.
5. An additional 7 experts opted to complete the questionnaire by sending emails and returning it via mail to the researchers. These additional experts did not include any further comments.
6. All experts responded to the survey questions and provided an explanation of its intended purpose.
7. The researcher categorized the experts' responses into similar and dissimilar groups in order to capture the prevailing consensus.
8. The researcher collected interview data using a semi-structured questionnaire and designed another questionnaire based on three aspects of learning engagement: behavioral, emotional, and cognitive engagement. The second questionnaire used a five-point Likert scale. Data analysis involved frequency and percentage calculations as well as the computation of mean (M), standard deviation, and correlation across the five scales. Respondents' agreement levels were categorized into different ranges, with an average score of 1.00-1.49 indicating strong disagreement and an average score of 4.50-5.00 indicating strong agreement.

Round 2 : Expert review

using the five-point Likert scale from Questionnaire I.

The passage is restated as follows:

1. The researcher took the initiative to contact 17 experienced professionals via phone in order to invite them to participate in a study utilizing the Delphi technique.

2. Upon receiving favorable feedback from all 17 eligible professionals, the researcher issued a formal invitation letter to enlist their participation in the study.
3. Scheduled appointments with all eligible professionals at requested dates and times.
4. 10 experts agreed to a personal meeting with the researchers, where Questionnaire II was distributed. Three of them gave feedback on the questionnaire during the meeting, which the researchers noted. Additionally, seven experts shared their perspectives in face-to-face meetings.
5. In addition, 7 experts opted to complete Questionnaire II by email and returned the survey to the researcher without providing any additional feedback.
6. The researchers then examined recent data from the initial set of open-ended surveys to confirm if agreement had been achieved. They chose pertinent elements from the findings of a partially structured interview questionnaire.
7.The researchers ultimately constructed a graph using the collective findings regarding similarities and disparities, indicating that decision trees excel in a particular area(Strawbridge , 2007).
8. The researchers collected data from 17 experts through emails or face-to-face interviews.
9. The numerical values of each question item were measured, including the mean, standard deviation, and coefficient of variation.
10. Based on the four principles (comprehensiveness, accuracy, scientificity, process) and the three dimensions of learning engagement (behavioral engagement, cognitive engagement, emotional engagement), the researchers constructed a blended learning engagement evaluation system framework .

Round 3: Reassessment

In the third round, these thoughts were assessed using a five-point Likert scale from Questionnaire II .
1.The selection of items from Questionnaire II encompasses first-level, second-level, and third-level indicators.
2.Consolidate the findings as either similarities or differences. Similarities indicate consensus among the 17 experts, while differences signify dissenting opinions. These combined results were utilized in formulating Questionnaire III.
3.Arrange meetings with all eligible experts at their preferred date and time.
4.The researcher is permitted to conduct face-to-face interviews with 10 experts, during which Questionnaire III was distributed and discussed. Three experts provided feedback in person while seven others shared their opinions for note-taking by the researcher.
5.Seven experts opted to complete Questionnaire II via email and returned it without additional comments.
6.Create a framework for assessing blended learning engagement within tertiary educational institutions
7.Once Questionnaire III was completed by the researcher ,the framework for evaluating investment in blended learning within colleges and universities was established

Round 4: Determine the plan

In the fourth round of research , after identifying viable concepts, the experts reached a decision and submitted a report. In addition, the experts acknowledged all the panel's points and considered the execution plan and details.

AHP hierarchy analysis calculates weights

In order to construct a comprehensive evaluation index system in the study, we first sorted out the first-level indicators, the second-level indicators to which these first-level indicators belong, and the third-level indicators under the second-level indicators, and used them to construct a judgment matrix and then form a questionnaire IV. Then, the researchers distributed Questionnaire IV to 17 experts, asking them to compare each item in the judgment matrix pairwise and give scores according to their importance. Then, for each indicator, the research team calculated the average of the scores provided by 17 experts to arrive at the final judgment matrix value.

Subsequently, the study uses a weight calculation formula to calculate the weight of each indicator. This process helps determine a complete evaluation indicator system and ensures that the relative importance of each indicator is reasonably considered.

3.2.5 Statistical analysis

1. Questionnaire Analysis:

The unbiased assessment of experts' reevaluation views on assessment criteria necessitates a quantitative analysis of their scoring information. Extensive research has demonstrated that expert evaluations rely on the mean (M) for central tendency, the standard deviation for spread, and the coefficient of variation for variability. The mean signifies the average rating given to each evaluation criterion by the experts, while the standard deviation quantifies how dispersed experts' ratings are around a specific criterion. The coefficient of variation represents the ratio of the standard deviation to its corresponding mean value. A larger coefficient indicates greater data dispersion, whereas a smaller one suggests less dispersion in data points. When revising evaluation criteria, those with higher mean values, lower standard deviations, and smaller coefficients should be prioritized and retained as critical indicators. Conversely,,criteria with lower means, larger standard deviations,and higher coefficients may require additional consideration or alternative treatment options.Entries in Table 3.1 presenting these means allow for an examinationof noteworthy disparities in respondents' viewpoints

Table 3.1 Mean and level of experts’ opinions of Learning engagement indicators

No.	M	Level of opinions
1.	1.00 – 1.49	Strongly disagree
2.	1.50 – 2.49	Disagree
3.	2.50 – 3.49	Neutral
4.	3.50 – 4.49	Moderately agree
5.	4.50 – 5.00	Strongly agree

Note: M = mean.

Different levels of standard deviation indicate the distribution of a dataset from its mean(Wongrattana, 2003). The standard deviation changes depending on how the data is distributed, giving us information about the distribution's properties and the distance between individual data points and the mean. This aids in a thorough examination and understanding of variability within a set of data.

0.000-0.999 means less spread apart data
More than 1.000 means more spread apart data

The Coefficient of Variation is a statistical metric utilized to assess the relative dispersion within a dataset. It is commonly used for comparing variability across various datasets. The formula for computing the Coefficient of Variation is expressed as:

CV = (Standard Deviation / Mean) × 100%

Note: Standard Deviation is a measure of how spread out the data is, while Mean shows the average value in the dataset. The Coefficient of Variation can be obtained by dividing Standard Deviation by Mean and then multiplying the result by 100%. A smaller CV suggests that the data is concentrated around the mean, indicating lower dispersion. Conversely, a larger CV value indicates greater variability in the data, suggesting higher dispersion.

This study indicates that the average M is greater than 3.5 (which represents 70% of the five-level rating scale). The standard deviation SD is less than 1, and the coefficient of variation CV, which is calculated as the ratio of SD to M, measures variability relative to the mean and yields a value lower than 0.25. (Bike, Z., & Ruichang,W. , 2023) .

2.Weight Analysis:

We utilize the Analytic Hierarchy Process (AHP) to determine the weights:

(1). Establish the hierarchy: Connections between audit content and audit evaluation indicators result in the hierarchical grouping of relevant indicator elements. The evaluation system for assessing investment in blended learning at universities is categorized into four levels: A for the evaluation system, B for three top-level indicators, C for ten second-level indicators, and finally D for 27 third-level indicators.

(2) .Construct the Importance Judgement Matrix:Once the hierarchy is established, matrices for judgment are employed to assess the relative significance of each element in relation to its superior indicator. A scale ranging from 1 to 9 is utilized for gauging the importance of each indicator.

Table 3.2 Scale definition of Judgement Matrix

Scale	Meaning
1	Equal importance
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments
1/bi	Represents an anti-comparison of the two elements

Note: The table presents the significance levels for the assessment matrix, indicating the comparative importance of judgments made by experts for each criterion.

Table 3.3 Importance Pairwise Comparison Judgment Matrix A

A	A1	A2	A3
A1	1	a_{12}	a_{13}
A2	$a_{21}=1/a_{12}$	1	a_{23}
A3	$a_{31}=1/a_{13}$	$a_{32}=/a_{23}$	1

Note: If element A1 holds greater significance than element A2, the ratio of A1/A2 will be higher. When element A1 is significantly more important than element A2, the value of A1/A2 is 9; conversely, when element A1 is only somewhat more important than small and not significant in comparison to around it, then the ratio becomes 1/9.

The research involved seventeen specialists who were asked to evaluate the judgment matrices by comparing them in pairs and assigning ratings based on their perceived significance through a questionnaire. The average score for each item was then computed, leading to the final values of the judgment matrices. Each expert individually assessed the importance of every indicator, forming the foundation for creating the relative importance judgment matrix.

(3).Calculation of Weights for Evaluation Indicators: The geometric average of each row in the decision matrix is calculated using the Geometric Mean Method($\overline{w_i}$).

$$\overline{w_i} = \left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}} \quad i,j=1,2\ldots.,n$$

In the equation, symbolizes the element in the i and j column of the initial judgment matrix, while n stands for the total number of indicators. denotes the geometric mean of the i-th row in the original judgment matrix. The geometric mean values from each row are subsequently standardized to derive the characteristic vector:

$$w_i = \frac{\overline{w}_i}{\sum_{j=1}^{n} \overline{w_j}} \quad i,j=1,2\ldots.,n$$

The formula involves the representation of the indicator's weight. Deriving the specific evaluation indicator's weight value requires multiplying its weight by that of its corresponding dimension and rounding off the result. This iterative process leads to the development of a weighted system for evaluating engagement in blended learning mode.

(4) .Single-level sorting and consistency test: Single-level sorting is used to determine the weight of each indicator in comparison with its higher-level counterpart within a single hierarchy. The purpose of the consistency test is to ensure the scientific validity of conclusions given the multidimensionality and complexity of evaluation indicators. During pairwise comparisons among various indicators' relative importance, inconsistent or contradictory conclusions may arise. Hence, a consistency test is conducted to guarantee the reliability of results. The calculation involves determining the maximum eigenvalue and eigenvector for matrix A as well as finding the consistency index CI, which measures differences between given pairwise comparison matrices and complete consistency matrices. Additionally, a pre-defined value called Random Index based on matrix size helps evaluate acceptable differences by calculating Consistency Ratio, which determines whether judgments are reliable enough for decision-making if CR < 0.1, indicating good consistency.

$$\lambda max = \frac{1}{n}\sum_{k=1}^{n}\frac{(AW_i)}{w_i}$$

Substitute the calculated λmax value into the given formula to determine the consistency indicator value:

$$CI = \frac{(\lambda\, max - n)}{(n-1)}$$

Finally, the consistency assessment indicator CR is calculated using the formula based on the average random consistency indicator value shown in Table 3.4.

$$CR = \frac{CI}{RI}$$

Table 3.4 Values for Average Random Consistency Index (RI) for Orders 1 to 11

n	2	3	4	5	6	7	8	9	10	11
RI	0	0.58	0.89	1.12	1.24	1.32	1.41	1.45	1.49	1.52

In this research, we employed SPSSPRO software to calculate the weight and test the consistency of single-level sorting. The Random Index value of the second-order matrix for the consistency test is 0, indicating that the matrix itself is consistent and does not require further scrutiny.

3.3 Phase II: To Identify and Develop Blended Learning Engagement Evluation System for University in China

3.3.1 Participants

This study selected 100 teachers from 5 universities in Sichuan Province, China. The sample size was a total of 100 teachers. Proportional stratified random sampling was used, that is, sampling = (total sample size) * (population of each school) /total population.

3.3.2 Instruments

After four rounds of Delphi research, we successfully constructed a framework of investment evaluation indicators for blended learning in colleges and universities. However, indicators alone are not enough to achieve a comprehensive assessment, so we need to perform a weighting calculation. This step is critical in determining the relative importance of each metric in the overall evaluation. Once the indicator items are assigned corresponding weights, we can get a complete evaluation system, which will more accurately reflect the different aspects of blended learning engagement. In order to finalize the evaluation system, we designed Questionnaire V and invited 100 teachers to evaluate the blended learning engagement evaluation system. Through this step, we are able to obtain feedback and opinions from a wide range of education professionals, helping us to more accurately determine the relative importance of various indicators, thereby further improving our evaluation system. This process is very critical because it ensures that our evaluation system is more credible and effective in practical applications.

3.3.3 Data Collection

Through surveys and participatory observations, the blended learning engagement evaluation system was determined as follows:

1. The researchers contacted five qualified universities and used simple random sampling to select 100 teachers with experience in blended teaching.

2. After securing approval from the aforementioned five universities, the researchers sent a formal invitation letter to RMUTT University.

Table 3.5 Statistical table of 100 teachers participating in the questionnaire

Sampling No.	Universities	Population	Sampling
1	Southwest Petroleum University	2853	21
2	Sichuan Normal University	2763	20
3	China West Normal University	2842	21
4	Chengdu University of Technology	2452	18
5	Sichuan University of Science and Engineering	2585	19
Total		13495	100

3. For these 100 teachers, they preferred to fill in the questionnaire we designed by email and returned it to the researcher. These participants provided no other additional comments or feedback

4. Finally, after the researchers completed the data collection of Questionnaire V, they established a complete model of the investment evaluation system for blended learning in colleges and universities. This model will help us more fully understand and evaluate various aspects of blended learning inputs in university settings.

3. 3. 4 Statistical Analysis

The initial research was conducted by teachers. The survey is based on "confirmation" or "disconfirmation" and "rejection" of Questionnaire III . Data were analyzed using frequencies and percentages to determine the opinions of 100 teachers on various evaluations in the process of determining the evaluation system for blended learning engagement.

3.4 Application of evaluation system for blended learning engagement in colleges and universities

3. 4 .1 Participants

Sichuan University of Science and Engineering consists of 19 colleges with a total of 39,325 undergraduate students and 1,928 teachers. Among these teachers, 518 teachers have blended teaching experience and they are proficient in using blended teaching methods in teaching. In order to collect more opinions about them , we randomly selected 226 teachers from these teachers with blended teaching experience to answer our questionnaire. The random sampling formula is as follows:

$$n = \frac{N}{1+Ne^2}$$

These teachers can not only effectively use blended teaching methods, but also use online platform data, classroom observations, and student interviews (Deng Biyun, 2021) to provide timely evaluation and feedback to students. This will enable a more comprehensive understanding of students' learning situations and make corresponding adjustments and improvements to improve the quality of education.

3. 4 .2 Instruments

In order to evaluate the learning engagement of undergraduate students at Sichuan University of Science and Engineering, we adopted a pre-constructed evaluation system model and generated a formal questionnaire VI. This questionnaire is officially named "Blended Learning Engagement Evaluation Questionnaire in Colleges and Universities" and aims to gain an in-depth understanding of students' learning engagement and the application effects of blended learning methods. In order to ensure the credibility and validity of the questionnaire, we invited teachers with blended teaching experience in this university to participate in the evaluation. Not only are these teachers skilled in blended teaching methods, they can also provide valuable insights and perspectives that help us better understand students' learning experiences and levels of engagement. Through this evaluation process, we aim to provide schools with in-depth insights into student learning engagement in blended learning environments, as well as recommendations for improving teaching methods and strategies. This will help improve the quality of education, meet students' learning needs, and further promote the development and application of blended learning.

3. 4 .3 Data Collection

This study adopted an online questionnaire survey and sent questionnaires to 226 teachers, and finally obtained 210 valid questionnaires . Based on the collected questionnaires, the scoring results of the evaluation objects are analyzed .

3.4 .4 Statistical Analysis

The blended learning engagement evaluation index system constructed in this study combines qualitative and quantitative indicators, so it is impossible to use a single method in calculation. This is because blended learning inputs cover multiple aspects, including qualitative factors, which need to be quantified and reasonably classified. In addition, the evaluation of blended learning engagement usually needs to consider multiple factors at different levels, and the fuzzy comprehensive evaluation method can effectively deal with this problem. In view of the unique advantages of the fuzzy comprehensive evaluation method, we decided to use this method to evaluate students' investment in blended learning. The fuzzy comprehensive evaluation method helps transform qualitative indicators into quantifiable data and integrate them into a comprehensive evaluation framework. In this way, we can more fully and accurately assess student engagement in a blended learning environment, taking into account the complex interrelationships of various factors. This will provide us with deeper insights that can help improve educational practices and strategies for blended learning. Fuzzy comprehensive evaluation process: The specific comprehensive evaluation process is as follows:

1. Determine a set of evaluation indicators, as follows: First-level indicator set U, expressed as U={U1, U2, U3, U4}. Here, U represents the fuzzy phenomenon being evaluated, and Ui (i=1, 2, ⋯ m) represents the m factors that affect the fuzzy phenomenon U. The secondary indicator set includes U1={U11, U12, U13, ...}, U2={U21, U22, ...}, U3={U31, U32, ...}, and U4={U41, U42 , ...}. In addition, within the second-level indicator set U1, we also established a third-level indicator set U11={U111, U112, U113, U114, ...}.
2. Determine the set of comments for questionnaire evaluation

In this study, the set of comments was graded: 95 points for very consistent, 82.5 points for consistent, 67.5 points for unsure, 50 points for inconsistent, and 20 points for very inconsistent. Remember V={20, 50, 67.5, 82.5, 95}.

3. We established a single-factor fuzzy relationship matrix R, which maps a set of evaluation indicators (U set) to a set of reviews (V set). The representation of this matrix is as follows:

$$R=\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}$$

In this matrix, rij (where i=1,2,⋯ m; j=1,2,⋯n) represents the membership degree of the j-th level comment made for the i-th evaluation index. Specifically, the value of each rij is calculated by dividing the number of people in the corresponding comment set by the total number of returned questionnaires, thus forming a fuzzy relationship matrix. This matrix will help us understand and analyze the fuzzy relationship between different evaluation indicators and reviews more clearly.

4. Determine the index Ui weight

This study and the use of the AHP method to calculate the weight of the indicator system can directly obtain the weight vector.

A=(a1,a2,....am), where ai ≥ 0,1,2...m, represents the weight of the i-th indicator Ui in the indicator set U.

5. Establish comprehensive evaluation model B

By operating on the fuzzy relationship matrix, we synthesize A with R of each evaluation index, thus obtaining a comprehensive evaluation model B:

$$B=A \times R=(a1,\cdots am)\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix}=(b_1, \cdots b_m)$$

In our research, we adopted a weighted average comprehensive evaluation method (Zhang, Q., & Wang, X. , 2016). This method is based on the calculated membership degree of each evaluation index and the fuzzy relationship matrix of the evaluation system, while taking into account the weight of each index. Through this method, we can conduct fuzzy comprehensive evaluation at all levels, comprehensively consider the information of different indicators, and obtain the results of the comprehensive evaluation. Specifically, we first calculated the comprehensive score of each indicator under different evaluation levels based on the membership degree of each indicator and the fuzzy relationship matrix. Then, based on the weight of each indicator, these scores are weighted and averaged to obtain a comprehensive score for each evaluation level. This process enables a more comprehensive consideration of the contribution and importance of each indicator, thereby providing more accurate results for the comprehensive evaluation. Through this comprehensive evaluation method, we can better understand and evaluate the research object, taking into account the weight and ambiguity of each factor, helping to make more comprehensive and credible decisions.

6. The final calculation formula for the score of the evaluation index system is as follows:

Score of indicators at all levels α =

CHAPTER 4

RESULTS

4.1 Introduction

This chapter discusses the development of an assessment system for blended learning involvement in higher education institutions, focusing on two main aspects: descriptive analysis and significance analysis. By integrating these aspects, key findings from interview and survey data are effectively summarized, providing valuable insights into engagement with blended learning in colleges and universities. To develop the assessment system, the study utilized the Delphi technique – a commonly employed method for expert consensus modeling. Conducting multiple rounds of Delphi surveys allowed the researchers to gradually construct a comprehensive and specific evaluation index system by gathering opinions and insights from various experts while ensuring objectivity and reducing subjective bias impact. Subsequently, to determine the weight of evaluation indicators, the study applied Analytical Hierarchy Process, enabling researchers to compare and weigh relative importance layer by layer in order to obtain weight values for each indicator. This quantitative approach provides a basis for decision-making based on different indicators' roles within the evaluation system. Overall, this study extensively employed both Delphi technique and AHP method to establish a thoroughgoing yet reliable evaluation system that considers expert opinions while maintaining scientific rigor through data analysis methodology combination.To sum up,this will provide an important reference for the development and optimization of blended learning in colleges and universities, and also provide useful reference for the construction of evaluation systems in similar fields.

4.1.1 To synthesize the Various indicators of the Blended Learning Engagement Evaluation System

1.Delphi method

First Round: Brainstorming

The primary goal of this study is to comprehensively construct an evaluation system for engagement in blended learning in colleges and universities. To achieve this goal, the study took a series of orderly steps designed to ensure the comprehensiveness and effectiveness of the evaluation system. First of all, based on the components of the evaluation system and the theoretical basis of blended learning engagement, the study adopted an interview plan and conducted in-depth exchanges with experts in the professional field in the form of semi-structured interviews. The focus of this step is to gain valuable insights from experts on the construction ideas of the evaluation system, key indicators, and theoretical support for blended learning engagement. Based on the expert opinions obtained from the interviews and combined with the basic theoretical framework of blended learning engagement, the research will organize and summarize the interview results or the first round of brainstorming. This will help to initially determine the main elements of the evaluation system and clarify the relationship between the elements and possible influencing factors. Next, the research will start creating questionnaire I based on the results of the above preliminary work. This questionnaire will be systematic and comprehensive, covering the key elements and theoretical support mentioned in the preliminary interviews. The design of the questionnaire will give full consideration to the structure and expression of the questions to ensure that respondents can accurately understand the intention of the questions and provide reliable answers .

Second Round: Evaluation of the Experts' Ideas

For constructing a preliminary evaluation system framework, this study focuses on three key dimensions of learning engagement: behavioral engagement, cognitive engagement, and emotional engagement. These dimensions are considered to be important components in evaluating the engagement in blended learning in colleges and universities. During the evaluation process, special attention is paid to the specific indicators behind each dimension to ensure a detailed and comprehensive evaluation system. Experts will be assessed using a five-point Likert scale questionnaire or Questionnaire I to gain insight into their perceptions of each dimension and indicator. After the assessment results have been collected, the research will summarize and analyze the expert responses. Similarities will be summarized as points of expert consensus, meaning that a majority of the 17 experts have reached an agreement. Instead, differences will be viewed as disagreements in expert opinion, possibly involving differing views on a particular dimension or indicator. Then questionnaire II is compiled based on the results of the first round and used for the next round of expert evaluation.

Third Round: Re-Evaluation

The study will re-evaluate the initially constructed evaluation system for engagement in blended learning in colleges and universities. Through Questionnaire II , experts have evaluated different dimensions and indicators of learning engagement and provided a series of quantitative feedback data. These data will be used to verify and adjust the framework of the previously constructed evaluation system. Based on the results of Questionnaire II , the study will be able to determine which dimensions and indicators are recognized by the majority of experts and which aspects may be divided or require further discussion. Then, based on the experts' scoring results, the research will organize the next round of discussion. This round of discussion will focus on the analysis and interpretation of the scoring results, focusing on consensus and disagreement among experts on weight allocation. Through brainstorming, experts can delve into the importance of different dimensions and indicators to promote the finalization of the evaluation system. Finally, questionnaire III was prepared for the fourth round of evaluation.

Fourth Round: Resolved and Reported

Experts determine the model through questionnaire III, answers, and results obtained. Through Questionnaire III, experts will evaluate the importance of indicators in the form of "Yes" or "No" to determine the final evaluation model. This binary selection method helps to quickly obtain experts' opinions and provides an intuitive and simple method for constructing an evaluation system.

2. AHP hierarchy analysis and weight calculation:

The weight of an indicator is calculated by comparing the relative importance of two factors. Furthermore, the calculated priorities are appropriate only if the pairwise comparison matrix passes the consistency test. The first-level indicators, the second-level indicators to which the first-level indicators belong, and the third-level indicators to which the second-level indicators belong are constructed to judge and form a questionnaire IV. Questionnaire IV was sent to 17 experts, and the experts were asked to compare the judgment matrices in pairs, and based on Importance rating. Then average the scores of each item of the 17 experts to obtain the final judgment matrix value. According to the weight calculation formula, the weight of each indicator is calculated and a complete evaluation indicator system is determined. Calculating the weight of indicators by comparing the relative importance of different factors is a common method that can help build a comprehensive and objective evaluation system. In this process, consistency testing is a key step to ensure the accuracy of weight calculation. First, the study constructs a judgment matrix by constructing the first-level indicators, the second-level indicators to which the first-level indicators belong, and the third-level indicators to which the second-level indicators belong, and forms Questionnaire IV. This questionnaire will be distributed to 17 experts, asking them to make pairwise comparisons of different indicators in the judgment matrix and score them according to their relative importance. This comparison method can help experts clarify the importance of different indicators. The study will then collect scores from 17 experts for each comparison and calculate the average score for each comparison. This will produce a comprehensive judgment matrix that reflects expert consensus on the relative importance of different indicators. Based on the final judgment matrix, the study will use the weight calculation formula to calculate the weight of each indicator. These weights reflect the relative role of indicators at different levels in the evaluation system, thereby helping to establish a complete evaluation index system. The key to this process is consistency. The experts' answers will be tested for consistency before weighting is calculated. If the comparison matrix passes the consistency test, the calculated weights will be reliable. If it doesn't pass, adjustments or another discussion may need to be made to ensure the final weight calculation is credible.

.4.12 To Identify Blended Learning Engagement Evaluation System for University in China

Universities in Sichuan Province, China have always played an important role in the field of education in China. We randomly selected 100 university teachers from 5 universities in Sichuan Province as research subjects. The breadth of this sample helps us obtain more comprehensive and representative data. Then, we distributed Questionnaire IV to these teachers, and finally constructed a comprehensive blended learning engagement evaluation system based on the teacher ratings. This evaluation system will take into account teachers’ teaching methods, technology applications, student interaction and other factors to more comprehensively evaluate their performance in a blended learning environment.

.4.13 Application of blended learning engagement evaluation system in colleges and universities

To conduct a comprehensive evaluation of its students' blended **learning engagement.** We randomly selected 226 teachers with blended teaching experience to answer Questionnaire V. By collecting and analyzing the questionnaire data, we obtained the scores of students' engagement in blended learning at Sichuan Light Chemical University. Next, the obtained data were calculated and analyzed using the fuzzy comprehensive evaluation method. This method can comprehensively consider the weight and correlation of each evaluation indicator to more comprehensively evaluate teachers' investment in blended learning. Through this process, we obtained the scoring results for each indicator. The evaluation results were analyzed in depth and existing problems and causes were identified. These issues may involve the improvement of teaching methods, the improvement of technology applications, the strengthening of student interaction, etc. Based on these issues, we put forward corresponding countermeasures and suggestions to help teachers improve the quality of blended teaching.

By evaluating the learning engagement of teachers at Sichuan University of Science and Engineering, we aim to verify the effectiveness of the blended learning engagement evaluation index system and provide targeted improvement suggestions for the school to continuously improve the quality of education and promote education and teaching. Innovation and development. This research will provide valuable practical experience and guidance for blended education and help promote progress in the field of education.

4.2 Results

4.2.1 To synthesize the Various indicators of the Blended Learning Engagement Evaluation System

4.2.1.1 Expert Positivity Coefficient and Degree of Authority

Expert Positivity Coefficient and Authority level are used to evaluate the expertise and influence of an individual or entity in a specific field. They help understand a person or institution's trustworthiness and reliability in a certain field.

Expertise Score：

Expert Positivity Coefficient is an indicator used to measure the level of expertise of an individual or institution in a specific field. This is usually determined by examining their educational background, training experience, work experience, publications, research results, etc. People or institutions with a high expert positivity coefficient are considered to have deeper knowledge and experience in the relevant field, and therefore their advice and insights in this field are more credible.

Expert Authority:

Expert Authority is a measure of the influence and credibility of an individual or institution in a specific field. This is related to expertise, but more focused on their influence on other people or communities. An authoritative person or institution is usually widely recognized in their field, and their views and advice may have greater influence on decisions.

Based on the actual situation of this study, an expert advisory group composed of education experts (associate professors and above) from colleges and universities was established. Finally, 17 experts in educational technology from three universities were identified. The expert's positivity coefficient is the response rate of the expert consultation questionnaire and reflects the expert's participation. Recovery rate = (number of participating experts/number of total experts) × 100%. The expert consultation questionnaire has a recovery rate of over 60%, demonstrating a favorable level of recovery(Jiang Guohua, 1998). The response rates of the two rounds of consultation questionnaires are shown in Table 1. The four round was 100%, indicating that experts were highly involved and actively provided modification suggestions.

Table 4.1 Delphi Method Expert Positivity Coefficients

Project	First Round	First Round	First Round	First Round
Distribute Expert Consultation Questionnaire	17	17	17	17
Collect Expert Consultation Questionnaires	17	17	17	17
Expert Positive Engagement Score	100%	100%	100%	100%

The Level of Expert Authority: The level of expert authority serves as the foundation for assessing the trustworthiness of consultation findings and is established by both the basis for judging indicators and the expert's familiarity with them. A higher Ca and Cs lead to greater expert authority. The formula for determining Cr is: Cr=(Ca+Cs)/2. Higher values of Cr reflect increased credibility in expert opinion results. When Cr>0.7, it signifies high reliability in consultation outcomes(Li Yanyan, 2020).

Table 4.2 Expert Judgment Degree Assignments

Judgment Criteria	Large	Medium	Small
Based on Theoretical Analysis of Blended Learning Engagement	0.3	0.2	0.1
Practical Experience in Blended Teaching	0.5	0.4	0.3
Reference Literature and Materials	0.1	0.1	0.1
Visual Perception	0.1	0.1	0.1
Total	1	0.8	0.6

Table 4.3 Expert Familiarity Level Assignments

Familiarity Level	Quantitative Value
Very Familiar	1
Moderately Familiar	0.8
Fairly Familiar	0.6
Not Very Familiar	0.4
Unfamiliar	0.2

When Ca is greater than 0.8, it indicates that the judgment basis has a great influence on the experts (Wang Chunzhi, 2011). The closer Cs is to 1, the more familiar the experts are with the indicators (Zhang Yuqiang, 2021). Statistical results of four rounds of expert self-evaluation.

Table 4.4 Four Rounds of Expert Judgment Criteria

Total Score as the Judging Criterion	1	0.9	0.8	0.7	0.6
Number of Participants in the First Round	6	6	5	0	0
Number of Participants in the Second Round	7	6	4	0	0
Number of Participants in the Third Round	8	6	3	0	0
Number of Participants in the Fourth Round	9	7	1	0	0

Table 4.5 Familiarity Results from Four Rounds of Experts

Degree of Familiarity Score.	Very Familiar	Moderately Familiar	Fairly Famili ar	Not Very Familiar	Unfamiliar
Number of Participants in the First Round	7	6	4	0	0
Number of Participants in the Second Round	7	7	3	0	0
Number of Participants in the Third Round	8	6	3	0	0
Number of Participants in the Fourth Round	8	7	2	0	0

Table 4.6 Authority Level Results from Four Rounds of Experts

Iteration	Judgment Criterion （Ca）	Familiarity Level （Cs）	Authority Level （Cr）
First Round	0.906	0.835	0.871
Second Round	0.918	0.847	0.882
Third Round	0.929	0.859	0.894
Fourth Round	0.947	0.871	0.909

After four rounds of the Delphi method, the coefficients of expert judgment basis are consistently high, indicating that experts are significantly influenced by their judgment. The coefficients for expert familiarity also show a high level of expertise with values consistently above 0.8. The expert authority coefficients further confirm the experts' high degree of authority and strong reliability, making them suitable for discussing research topics.

4.2.1.2 Delphi method:

Round 1: Brainstorming

In the first round, a collaborative brainstorming session was held to define primary assessment standards. These standards were created by integrating input from a semi-structured survey, pertinent theories, and literature. Following this, Questionnaire I was formulated with the guidance of experts.

First, the experts were interviewed. The following is a summary of the questions answered by the experts:

Question 1: What is the concept of building a blended learning engagement evaluation system?

Expert conclusion: The concept of building a blended learning engagement evaluation system aims to deeply understand students' learning engagement in a blended learning environment in order to better support and optimize teaching practices. The blended learning engagement evaluation system can help educators, researchers and policymakers understand students' behavioral, cognitive, emotional and social performance in blended learning, thereby providing targeted solutions for improving learning effects and meeting student needs. guidance. The construction concept of this evaluation system is based on the following key points: 1. Multi-dimensional perspective: Blended learning involves the combination of multiple learning environments and learning methods, so the evaluation system should cover multiple dimensions, including behavior, cognition, and emotion. and social aspects. This provides a comprehensive understanding of student engagement in learning in different settings. 2. Individual differences: Different students may have different levels of investment in learning, so the evaluation system should be able to consider individual characteristics and needs. Personalized assessments help provide individual instruction and help each student fully participate in blended learning. 3. Support teaching optimization: One of the purposes of building an evaluation system is to provide educators with feedback on student engagement so that they can adjust teaching strategies based on student performance. Educators can better design course content, interactive activities, and support measures based on evaluation results. 4. Continuous improvement: The evaluation system should be a process of continuous improvement. As educational technology and learning environments change, evaluation indicators and methods also need to be constantly updated and adjusted. This helps maintain the validity and applicability of the evaluation system. 5. Comprehensive data: The evaluation system can combine quantitative and qualitative data, including student behavior records, questionnaires, interviews, etc., to obtain information about student engagement from multiple angles. This helps to obtain more comprehensive and accurate evaluation results. In short, the concept of building a blended learning engagement evaluation system is to better understand students' learning engagement in a blended learning environment, thereby optimizing teaching practices, improving learning effects, and meeting students' learning needs. This requires comprehensive consideration of indicators from multiple dimensions, paying attention to individual differences, supporting teaching optimization, maintaining continuous improvement, and combining multiple data sources.

Question 2: What principles should the blended learning learning engagement evaluation system follow?

Expert conclusions: 1. The principle of comprehensiveness, the construction of the indicator system must be based on the overall situation, and the proposed indicator system must fully consider the status of learners participating in online and offline learning. 2. Principle of accuracy. There are many indicators that reflect college students’ engagement in blended learning, and it is impossible to list all data collection items at all levels of dimensions. Therefore, when constructing the evaluation dimensions of blended learning engagement, it is necessary to select the most core and valuable indicators at all levels, which can provide guidance for evaluating the status of college students' investment in online learning. The evaluation results obtained through the constructed index system can be Feedback on online learning engagement must be accurate. 3. Scientific principle, construct a scientific theoretical basic framework, and ensure the rigor of the research process. When conducting applied research based on the constructed indicator system, ensure the authenticity and integrity of the collected data and support it with scientific calculation methods, thereby providing guarantee for the construction of a scientific indicator system and the results of applied research.

Question 3: What main dimensions do you think the blended learning engagement indicator system should include?

Expert conclusion: The blended learning engagement index system should include multiple main dimensions to comprehensively understand students' engagement and performance in a blended learning environment. These dimensions cover student engagement in behavioral, cognitive, emotional and social aspects, helping to more accurately assess student engagement in learning. Here are some of the main dimensions that should be included: 1. Behavioral Engagement: The behavioral engagement dimension focuses on students' actual engagement and activities in blended learning. This includes frequency and enthusiasm for participation in online discussions, class activities, assignment submissions, collaborative projects, etc. Measuring behavioral engagement can help understand whether students are actively engaged in learning activities. 2. Cognitive engagement: The cognitive engagement dimension focuses on students' thinking, analysis and understanding levels in blended learning. This includes the use of learning strategies, in-depth thinking, and independent problem-solving abilities. The evaluation of cognitive engagement can reveal students' mastery and application of learning content. emotional engagement: The emotional engagement dimension focuses on students' emotional attitudes and emotional expressions in blended learning. This includes aspects such as learning motivation, emotion management, learning satisfaction, and interaction with classmates and teachers. The evaluation of emotional engagement helps to understand students' learning motivation and emotional experience. Social Engagement: The social engagement dimension focuses on the extent to which students interact with classmates and teachers in blended learning. This includes aspects such as collaborative projects, online discussions, interactions with faculty, and more. Assessments of social engagement can reveal how engaged students are in the learning community.

Question 4: When determining investment indicators for blended learning, what key indicators do you think should be considered?

Experts' conclusions: 1. Online participation: measures students' activity on online platforms, such as login frequency, participation in discussions, online assignment submission, etc. 2. Course completion rate: Determine the percentage of students who complete online courses, reflecting the degree of student investment in the learning process. 3. Learning time: Record the time students spend in the online learning environment, including watching course videos, reading materials, etc. 4. Interactive participation: Examine the frequency of interactions between students, teachers and classmates, such as participating in discussions, asking questions, etc. 5. Autonomous learning: Assess students' autonomous learning abilities in blended learning, such as independently selecting learning content, formulating study plans, etc. 6. Feedback and evaluation participation: Examine the extent to which students participate in course evaluation and provide feedback, reflecting students' investment in course improvement. 7. Performance: Consider students' academic performance in blended learning, including test scores, homework ratings, etc. 8. Technology adaptability: Assess students' adaptability to online learning tools and technologies, reflecting students' investment in blended learning environments. 9. Active participation attitude: Understand students' attitude and willingness towards blended learning, and consider whether students are willing to actively participate in the learning process. 10. Learning motivation: Investigate students' intrinsic and extrinsic motivations for learning and understand students' willingness to invest in blended learning. These key indicators can help assess student engagement in blended learning to better optimize and improve instructional design and learning support.

Question 5: How to distinguish the investment in online learning and traditional face-to-face learning?

Expert conclusion: To distinguish between investment in online learning and traditional face-to-face learning, the following factors and methods can be considered:

1. Time management and flexibility: Observe students’ performance in time management. Online learning often requires greater self-management and time planning skills because study times are more flexible, whereas traditional face-to-face learning usually has a fixed course schedule. 2. Course Engagement: View student engagement in class or online courses. Interactions in traditional face-to-face classes are often more direct, whereas online learning may require students to participate more actively in discussion boards or online activities. 3. Learning outcomes: Compare students’ academic performance and learning outcomes under different modes. This can help determine which learning style is more suitable for them. 4. Learning motivation: Examine students’ learning motivation and interest. Online learning may require greater self-motivation and therefore a higher reliance on learning motivation. 5. Learning experience: Collect students’ experiences and feedback on online learning and traditional face-to-face learning. This feedback can provide information about student engagement and satisfaction. 6. Technology Use: Observe students’ proficiency in using technology tools and online platforms. Online learning may require more technical skills. 7. Learning strategies: Examine the learning strategies adopted by students in different learning modes. Online learning may require more self-directed study and independent research. 8. Interaction between teachers and classmates: Observe the interaction between students, teachers and classmates. In traditional face-to-face learning, interaction may occur more easily, whereas online learning requires more active interaction. By considering the above factors together, a more comprehensive distinction can be made between student engagement in online learning and traditional face-to-face learning. Different students may exhibit different levels of engagement in different learning environments, so multiple factors need to be considered.

Question 6: How to consider the differences between different disciplines and courses?

Expert summary: In research on blended learning inputs, it is crucial to consider differences across disciplines and courses, as different areas and courses may require different assessment methods and focuses. The following are some suggestions for considering the differences between different subjects and courses: 1. Nature of courses: First understand the nature of different subjects and courses. Some subjects may focus more on theoretical knowledge, while others may focus more on practical applications. This affects how students engage in and need learning. 2. Subject requirements: Consider the requirements and standards of each subject. Different subjects may require different learning strategies and skills, so the input will vary. 3. Assessment methods: Identify appropriate assessment methods for different subjects and courses. Some subjects may be better suited to exams and quizzes, while others may be better suited to project work or practical tasks. 4. Subject content: Consider the content complexity of different subjects. Certain subjects may be easier to understand, while others may require more in-depth thought and analysis. This may affect students' cognitive engagement. 5. Teaching methods: Consider the teaching methods used in different subjects and courses. Some courses may focus more on interaction and discussion, while others may focus more on independent study. 6. Subject culture: Consider the subject culture and educational traditions of different subjects. Some disciplines may be more focused on collaboration and experimentation, while others may be more focused on independent thinking and theory. 7. Student groups: Consider student groups in different disciplines and courses. Students with different backgrounds and learning styles may have different needs for learning engagement. 8. Teacher's role: Understand the role of teachers in different subjects and courses. Some teachers may focus more on guidance and coaching, while others may focus more on inspiring students to learn independently. By considering these factors together, researchers can better understand blended learning inputs across disciplines and courses and provide guidance for tailoring appropriate assessment tools and teaching strategies. This helps ensure the accuracy and applicability of research while improving the effectiveness of educational practice.

Question 7: How to ensure the reliability and validity of the evaluation system?

Expert summary: It is very important to ensure the reliability and validity of the evaluation system, especially in blended learning engagement research. Here are some key steps and strategies that can help ensure the reliability and validity of your evaluation system:1. Clearly define goals and indicators: First, clearly define the goals of the evaluation and the indicators to be measured. Make sure the objectives are clear and consistent with the research question to avoid vague or irrelevant measurements. 2. Establish appropriate measurement tools: Develop or adopt appropriate measurement tools, such as questionnaires, observation forms, or academic performance records. These tools should be able to accurately capture students' learning engagement 3. Consider reliability and validity: When designing the evaluation system, ensure that the measurement tools have good reliability (consistency and stability) and validity (accuracy and validity of measurement) applicability). Reliability testing and validity analysis were conducted to verify the quality of the measurement instrument. 4. Use multiple methods: Use a variety of different assessment methods to obtain more comprehensive data, such as self-reports, teacher assessments, academic performance, observations, and learning analytic. This helps reduce the bias that a single method may introduce. 5. Conduct preliminary testing: Before formal research, conduct preliminary testing or trial operation to evaluate the feasibility and acceptability of the evaluation system. Gather feedback and make adjustments. 6. Ensure sampling representative: Select representative samples to ensure the generalization of research findings. The sample should cover students from a variety of subjects, grade levels, cultural backgrounds, and ability levels. 7. Regular monitoring and adjustment: During the study period, the data quality and the effectiveness of the evaluation tools are regularly monitored, and adjustments and improvements are made as necessary. 8. Statistical analysis and data verification: Use appropriate statistical methods to analyze data to verify the reliability and validity of the evaluation system. Perform repeated measures, factor analysis, correlation analysis, etc. 9. Introduce expert opinions: absorb the suggestions and opinions of experts in the field to ensure the rationality and effectiveness of the evaluation system. 10. Feedback and improvement: Feed back evaluation results to teachers and students, and use these results to improve teaching practices. Ensure that the results of the assessment system have real value in increasing learning engagement. 11. Continuous monitoring and evaluation:

Continuously monitor and evaluate the evaluation system to ensure its reliability and effectiveness in different situations and time periods.

Academic researchers can develop a dependable and efficient assessment structure for participation in blended learning within both research and practical contexts by thoroughly examining these steps and tactics. This effort enhances the scholarly rigor of research and the effectiveness of educational implementation. Certain data concerning elements influencing engagement in learning, gathered from semi-structured surveys and literature review, are outlined below:

Table 4.7 Expert discussion results

Indicators	frequency
Behavioral Engagement	17
Emotional Engagement	17
Cognitive Engagement	16
Social Engagement	6
Indicators of Behavioral Engagement	**frequency**
Effort	5
Focus	17
Attendance	13
Attempt	7
Completing assignments	13
Positive behavior	8
Action	11
Confidence	6
Participation	17
Interaction	12
Seeking help from teachers or peers	12
Taking responsibility	3
Opportunities or challenges	13
Developing a variety of skills	7
Learning performance	14
Metacognitive strategies	6
Supporting and encouraging peers	4
Interaction(with peers,teachers,content,technology)	14
Study habits	8
Trying feedback	6
Engaging in discussion topics	4
Self-evaluation and reflection	15
Setting learning goals	13
Task time	13

Evasion	6
Reaction	5
Persistence	13
Indicators of Cognitive engagement	frequency
Knowledge integration	11
Critical thinking	13
Self-directed time	12
Innovative thinking	14
Argumentation	5
Induction	12
Academic Challenges	10
Reflection	13
Summarization and Induction Ability	10
Peer learning	6
Rational decision-making	4
Self-efficacy	11
Learning strategies	10
Self-monitoring of Learning	6
Perceived teacher support	3
Input Method	6
Memory/recall	7
Analysis	14
Indicators of Emotional engagement	frequency
Enthusiasm	11
Sense of belonging	16
Curiosity	7
Relevance	8
Interest	14
Happiness	11
Emotional attitude	12
Appreciation	7
Emotional transfer	13
Cognitive reappraisal	10
Desire for success	1
Reward	9
Value	13
Indicators of Social Engagement	frequency
Online attendance rate	14
Discussion participation level	15
Collaborative project engagement level	10

Self-directed learning time	11
Social interaction tool usage rate	13
Project completion rate	13
Interaction feedback time	15

We gleaned some key insights from the table above about engagement in blended learning, which can be divided into three main levels: behavioral engagement, emotional engagement, and cognitive engagement. In terms of behavioral engagement, we can see that more than half of the engagement indicators include: concentration, participation, self-evaluation and reflection, learning performance, interaction with others (including peers, teachers, content and technology interaction), attendance, homework completion, coping Opportunities and challenges, setting learning goals, time management on tasks, persistence, interactivity, and asking for help from teachers or peers when needed. It is worth noting that based on expert advice, some indicators of social investment and behavioral engagement overlap, so we decided to integrate these indicators into behavioral engagement. These integrated metrics include online attendance, discussion participation, collaborative project participation, independent learning time, use of social interaction tools, project completion rate, and interactive feedback time. In addition, experts also suggested that we initially identify secondary indicators of behavioral engagement, including: focus, participation, persistence, and interaction. Furthermore, to better refine the assessment of behavioral engagement, we integrated self-evaluation feedback and goal setting as secondary indicators of self-monitoring. The remaining engagement indicators are considered tertiary indicators, which will help us assess behavioral engagement levels in blended learning environments in more detail. When formulating the third-level indicators, we will comprehensively consider factors in both online and classroom situations to ensure the comprehensiveness and applicability of the evaluation indicators. Finally, we obtained preliminary secondary and tertiary indicators of behavioral engagement as follows:

Table 4.8 Behavioral Engagement Assessment Indicators

Level 1	Level 2	Level 3
Behavioral Engagement	Participate	Number of Online Platform Logins,Online Platform Task Completion,Frequency of Answering Questions In Class
	Focus	Video Learning Time,Amount of Classroom Tasks Completed ,Discussion Popularity on Online Platforms
	Interaction	Peer Reviews and Feedback,Teacher-student Interaction,Overcome Difficulties
	Persistence	Online Task Persistence,Maintaining a High Level of Engagement In Classroom,Classroom Study Time
	Self-monitoring	Clarify goals and requirements,Self-evaluation and reflection,Learning Tool Use

In terms of Cognitive engagement, experts evaluated a series of indicators. The most selected ones were innovative thinking, analysis, logical and critical thinking, reflection, independent study time, understanding, knowledge integration, self-efficacy, academic challenge, summary and Generalization skills and learning strategies. It is worth noting that indicators such as logical critical thinking, innovative thinking, analysis, and understanding all reflect the level of self-awareness and deep learning, while knowledge integration involves the category of learning strategies. Therefore, we further subdivided cognitive engagement into two secondary indicators: self-management and learning strategies. Under the second-level indicator of self-management, innovative thinking and logical and critical thinking are identified as third-level indicators. Under the second-level indicator of learning strategy, analysis, summary and induction abilities can be integrated into a third-level indicator. At the same time, according to the suggestions of experts, other indicators can also be further divided into three-level indicators, as follows:

Table 4.9 Cognitive Engagement Assessment Indicators

Level 1	Level 2	Level 3
Cognitive Engagement	Self-Management	Logic and Critical Thinking,Creative Thinking and Problem Solving ,Autonomous Time
	Learning Strategies	Summarization and Induction,Ability,Self-test and Rhetorical Questions

In terms of emotional engagement, experts selected more than half of the following indicators: belonging, interest, emotional transfer, value, emotional attitude, happiness, enthusiasm, rewards, and cognitive reappraisal. It should be noted that interest is an emotional attitude, while happiness and enthusiasm are related to intrinsic personality traits, and rewards are part of external motivation. Therefore, we can formulate secondary indicators as affective attitudes, intrinsic support, and external support. Based on expert opinions, we can further derive the following three-level indicators:

Table 4.10 Emotional Engagement Assessment Indicators

Level 1	Level 2	Level 3
Emotional Engagement	Self Worth	Identity, Sense of Belonging
	Emotional Attitudes	Habit,Interest,Sense of Accomplishment
	Internal Support	Cognitive Reappraisal,Emotional Transfer,Self encouragement
	External Support	Force,Award

Based on the indicators developed above, a preliminary framework was formed, and Questionnaire I was developed for the next round of expert discussion.

Round 2: Expert review

Questionnaire I was utilized to collect ratings from 17 experts regarding the indicators. Data analysis was conducted using SPSS software, where the mean (M) was employed to indicate expert agreement (M > 3.5). Standard deviation (SD) and coefficient of variation (CV) were used to assess expert opinions (SD < 1, CV < 0.25, indicating consensus among experts). The test results are as follows:

Table 4.11 Statistical table of level 1 indicators

Level 1	Sample	Mean M	Standard Deviation SD	Coefficient of Variation CV
Behavioral Engagement	17	4.23	0.323	0.076
Cognitive Engagement	17	4.02	0.387	0.096
Emotional Engagement	17	4.18	0.314	0.075

Alpha=0.939, indicating strong reliability. There are three first-level indicators, “Behavioral Engagement”, “Cognitive Engagement”, and “Emotional Engagement”. The average values are: "4.23", "4.02", and "4.18". The average values are all greater than 3.5. It indicates that the expert recognition is high and the standard for evaluating indicators is The differences are all less than 1, indicating that the opinions among experts are concentrated and consistent. In addition, the coefficient of variation of each indicator is below 0.25, further strengthening the concept of strong consensus and convergence on these indicator systems. Therefore, these three indicators can be retained without deletion, and there is no need to consult on this project in the next round of consultation.

Table 4.12 Statistical table of level 2 indicators

Level 2	Sample	Mean M	Standard Deviation SD	Coefficient of Variation CV
Participate	17	4.41	0.559	0.127
Focus	17	3.88	0.416	0.107
Interaction	17	4.45	0.31	0.070
Persistence	17	3.94	0.455	0.115
Self-monitoring	17	4.32	0.397	0.092
Self-Management	17	3.88	0.401	0.103
Learning Strategies	17	3.91	0.333	0.085
Self Worth	17	4.2	0.459	0.109
Emotional Attitudes	17	4.34	0.431	0.099
Internal Support	17	3.98	0.253	0.064
External Support	17	2.82	0.585	0.207

Alpha=0.874, indicating strong reliability. In the secondary indicators, the mean value of the indicator item "External Support" is 2.82 which is less than 3.5, indicating that experts do not agree with this indicator and should be deleted. The scores of the remaining indicators are all greater than 3.5, the standard deviations are all less than 1, and the coefficients of variation are all less than 0.25, indicating that the degree of consensus and recognition among experts is high, and the experts have unanimous opinions, and these indicators can be retained. Therefore, we will delete the "external support" indicator from the secondary indicators. According to expert feedback, college students mainly cultivate analytical and problem-solving abilities. Through learning, students develop the ability to analyze problems, think independently, and solve problems. They learn to see problems from multiple perspectives and use logic and creative thinking to find solutions. Critical thinking, college studies emphasize critical thinking, which is the ability to evaluate, analyze and debate information and opinions. Students learn to question and evaluate the reliability and plausibility of information. Based on expert opinions, although I agree with the following indicators, the name can be revised to a more targeted name, so "Self-Management" is changed to "Depth of thinking" and "Internal Support" is changed to "Emotion Regulation". "Emotional Attitudes" was changed to "Emotional Experience".

Table 4.13 Statistical table of level 3 indicators

Level 3	Sample	Mean M	Standard Deviation SD	Coefficient of Variation CV
Number of online platform logins	17	4.41	0.618	0.140
Amount of online tasks completed	17	4.47	0.717	0.160
Frequency of answering questions in class	17	4.47	0.624	0.140
Video learning time	17	3.82	1.015	0.266
Amount of classroom tasks completed	17	4.29	0.588	0.137
Discussion popularity on online platforms	17	4.53	0.8	0.177
Peer Reviews and Feedback	17	4.47	0.514	0.115
Teacher-student interaction	17	4.35	0.606	0.139
Overcome difficulties	17	4.18	0.809	0.194
Online Task Persistence	17	4.41	0.795	0.180
Maintaining a high level of engagement in the classroom	17	4.47	0.8	0.179
Classroom study time	17	2.41	0.507	0.210
Clarify goals and requirements	17	4.41	0.618	0.140
Self-evaluation and reflection	17	4.41	0.795	0.180
Learning tool use	17	3.71	1.047	0.282
Logic and Critical Thinking	17	4.18	0.529	0.127
Creative Thinking and Problem Solving	17	4.24	0.831	0.196
Autonomous Time	17	2.47	0.514	0.208
Summarization and Induction Ability	17	4.35	0.606	0.139
Qelf-test and rhetorical questions	17	4.47	0.514	0.115
Identity	17	4.47	0.717	0.160
Sense of belonging	17	4.47	0.624	0.140

Habit	17	2.94	0.429	0.146
Interest	17	4.35	0.786	0.181
Sense of accomplishment	17	4.53	0.514	0.113
Cognitive reappraisal	17	4.35	0.702	0.161
Emotional transfer	17	4.41	0.507	0.115
Self encouragement	17	2.82	0.529	0.188
Force	17	2.76	0.437	0.158
Award	17	2.59	0.507	0.196

Alpha=0.828 demonstrates high reliability. The average scores for "Classroom study time", "Autonomous Time", "Habit", "Self encouragement", "Force" and "Award" are 2.41 and 2.47 respectively, lower than the threshold of 3.5 points, which suggests a lack of consensus among experts regarding these indicators, prompting the need to remove them from consideration.Additionally, the mean scores for "video learning time" and "learning tool use" are 3.82 and 3.71 respectively, surpassing the threshold of 3.5 points. However, both indicators have standard deviations exceeding 1, and coefficients of variation greater than 0.25, suggesting that while experts generally concur with their assessments, there is considerable controversy and lack of consensus in expert opinions.According to expert opinions, we need to correct some indicator before we can keep it, otherwise we need to delete it. Therefore, we convert the indicator into "The amount of video played per unit time" and "Learning environment adjustment" before proceeding to the next step. Based on the feedback from experts, blended learning should also pay attention to inspections in the classroom, so we also need to add indicators "classroom attendance" and "Classroom performance" to the secondary indicators. Combined with the goal of cultivating students in colleges and universities, "Interdisciplinary Thinking and Associations" is added. Aside from the unsuccessful indicators mentioned earlier, the mean values of other indicators exceed 3.5, with all their standard deviations less than 1 and coefficients of variation below 0.25. These findings suggest strong data convergence and consistent expert opinions, warranting their retention.

Round 3: Reassessment

After necessary adjustments, the first-level indicators were unanimously agreed by the experts in Questionnaire I. Therefore, in Questionnaire II, there is no need to score the main indicators. Questionnaire II was evaluated by experts within the framework of a rigorous educational research paradigm. The test results are as follows:

Table 4.14 Statistical table of level 2 indicators

Level 2	Sample	Mean M	Standard Deviation SD	Coefficient of Variation CV
Participate	17	4.41	0.712	0.161
Focus	17	4.35	0.702	0.161
Interaction	17	4.53	0.624	0.138
Persistence	17	4.41	0.618	0.140
Self-monitoring	17	4.65	0.606	0.130

Depth of thinking	17	4.47	0.624	0.140
Learning Strategies	17	4.53	0.624	0.138
Self Worth	17	4.71	0.588	0.125
Emotional Experience	17	4.41	0.618	0.140
Emotion Regulation	17	4.71	0.470	0.100

Alpha=0.849, indicating strong reliability.The data shows a strong agreement and focus among the experts. All indicators have average scores higher than 4, and their variability is less than 1, suggesting that the opinions of the experts are focused. Additionally, all coefficients of variation are below 0.25, indicating a consistent and convergent indicator system. As a result, this indicator can be seen as reliable and effective.

Table 4.15 Statistical table of level 3 indicators

Level 3	Sample	Mean M	Standard Deviation SD	Coefficient of Variation CV
Number of online platform logins	17	4.18	0.529	0.127
Online platform task completion	17	4.29	0.849	0.198
Frequency of answering questions in class	17	4.29	0.588	0.137
classroom attendance	17	4.35	0.606	0.139
The amount of video played per unit time	17	4.35	0.862	0.198
Amount of classroom tasks completed	17	4.18	0.636	0.152
Classroom performance	17	4.59	0.618	0.135
Discussion popularity on online platforms	17	4.53	0.624	0.138
Peer Reviews and Feedback	17	4.35	0.606	0.139
Teacher-student interaction	17	4.59	0.795	0.173
overcome difficulties	17	4.41	0.618	0.140
Online Task Persistence	17	4.41	0.618	0.140
Maintaining a high level of engagement in the classroom	17	4.35	0.702	0.161
Clarify goals and requirements	17	4.41	0.795	0.180
Self-evaluation and reflection	17	4.29	0.588	0.137

Learning environment adjustment	17	4.65	0.493	0.106
Logic and Critical Thinking	17	4.41	0.618	0.140
Creative Thinking and Problem Solving	17	4.06	0.748	0.184
Interdisciplinary Thinking and Associations	17	4.12	0.697	0.169
Summarization and Induction Ability	17	4.47	0.514	0.115
Self-test and Rhetorical Questions	17	4.41	0.870	0.197
Identity	17	4.35	0.606	0.139
Sense of Belonging	17	4.35	0.862	0.198
Sense of Accomplishment	17	4.29	0.772	0.180
Interest	17	4.65	0.493	0.106
Cognitive Reappraisal	17	4.41	0.618	0.140
Emotional Transfer	17	4.47	0.514	0.115

Alpha=0.911, indicating strong reliability. The indicators demonstrate a high level of consensus and concentration among the experts. All indicators have mean scores above 4, and their standard deviations are below 1, indicating that the expert opinions are concentrated.Furthermore, all coefficients of variation are below 0.25, reflecting the consistency and convergence of the indicator system. Therefore, this evaluation indicator system can be considered effective and reliable.

Round 4: Determine the plan

Based on the results of Questionnaire II, the first indicator and the corresponding secondary and tertiary indicators are determined, and Questionnaire III is compiled. Experts are required to answer Yes or No according to the questionnaire. The results are as follows:

Table 4.16 Expert Opinions on the Higher Education Blended Learning Engagement Assessment System

No.	Indicator	Yes Response Percentage	No Response Percentage	Unsure Response Percentage
a.Behavioral Engagement				
1	Participate	94.1	0.0	5.9
1.1	Number of Online PlatformLogins	94.1	0.0	5.9
1.2	Online Platform Task Completion	94.1	0.0	5.9
1.3	Frequency of Answering Questions In Class	82.4	5.9	11.8

1.4	Classroom Attendance	82.4	5.9	11.8
2	Focus	82.4	5.9	11.8
2.1	The Amount of Video Played Per Unit time	88.2	5.9	5.9
2.2	Amount of Classroom Tasks Completed	94.1	0.0	5.9
2.3	Classroom Performance	88.2	5.9	5.9
3	Interaction	82.4	5.9	11.8
3.1	Discussion Popularity On Online Platforms	82.4	5.9	11.8
3.2	Peer Reviews and Feedback	88.2	5.9	5.9
3.3	Teacher-Student Interaction	82.4	5.9	11.8
4	Persistence	82.4	11.8	5.9
4.1	Overcome Difficulties	88.2	5.9	5.9
4.2	Online Task Persistence	82.4	11.8	5.9
4.3	Maintaining a High Level Of Engagement In The Classroom	82.4	11.8	5.9
5	Self-monitoring	82.4	5.9	11.8
5.1	Clarify Goals and Requirements	88.2	5.9	5.9
5.2	Self-evaluation and reflection	82.4	11.8	5.9
5.3	Learning Environment Adjustment	88.2	5.9	5.9
b.Cognitive Engagement				
1	Depth of thinking	88.2	5.9	5.9
1.1	Logic and Critical Thinking	82.4	11.8	5.9
1.2	Creative Thinking and Problem Solving	82.4	11.8	5.9
1.3	Interdisciplinary Thinking and Associations	88.2	5.9	5.9
2	Learning Strategies	88.2	5.9	5.9
2.1	Summarization and Induction Ability	82.4	11.8	5.9
2.2	Self-test and Rhetorical Questions	88.2	5.9	5.9
c.Emotinal Engagement				
1	Self Worth	82.4	5.9	11.8
1.1	Identity	88.2	5.9	5.9
1.2	Sense of Belonging	82.4	11.8	5.9
2	Emotional Experience	88.2	5.9	5.9
2.1	Sense of Accomplishment	88.2	5.9	5.9
2.2	Interest	82.4	5.9	11.8
3	Emotional Regulation	82.4	5.9	11.8
3.1	Cognitive Reappraisal	88.2	5.9	5.9
3.2	Emotional Transfer	82.4	11.8	5.9

4.2.2 AHP analytic hierarchy process calculation weight:

To ensure the accuracy and comprehensiveness of the evaluation results, it becomes imperative to assign appropriate weights to each indicator under the respective dimensions. This step is crucial for establishing a robust and feasible evaluation indicator system. The integration of the Analytic Hierarchy Process (AHP) and Delphi methods allows for the determination of indicator weights, leading to a comprehensive and operational evaluation indicator system. The resulting system serves as a scientifically accurate foundation for measuring the degree of engagement in blended learning at universities.The software SPSSPRO is employed to calculate the weight values and perform consistency tests for each indicator. Notably, consistency testing is not required for the second-order matrix since the RI value is 0, and the second-order matrix itself is consistent. The judgment matrix calculation process will be displayed in the Appendix .IThe evaluation system's respective weights have been determined as follows table:

Table 4.17 Weight of Evaluation Indicators for Blended Learning Engagement

Level 1	Weight	Level 2	Weight	Composite Weight	Level 3	Weight	Composite Weight
Behavioral Engagement	0.5680	Participate	0.1386	0.0787	Number of online platform logins	0.3903	0.0308
					Online platform task completion	0.2922	0.0231
					Frequency of answering questions in class	0.1944	0.0154
					classroom attendance	0.1231	0.0097
		Focus	0.3431	0.1949	The amount of video played per unit time	0.1353	0.0264
					Amount of classroom tasks completed	0.5007	0.0976
					Classroom performance	0.3640	0.0710

		Interaction	0.1476	0.0838	Discussion popularity on online platforms	0.4664	0.0391
					Peer Reviews and Feedback	0.3136	0.0263
					Teacher-student interaction	0.2200	0.0185
		Persistence	0.1205	0.0684	overcome difficulties	0.1676	0.0115
					Online Task Persistence	0.5292	0.0363
					Maintaining a high level of engagement in the classroom	0.3032	0.0208
		Self-monitoring	0.2503	0.1422	Clarify goals and requirements	0.2736	0.0389
					Self-evaluation and reflection	0.1508	0.0215
					Learning environment adjustment	0.5756	0.0819
Cognitive Engagement	0.1914	Depth of thinking	0.3269	0.0626	Logic and Critical Thinking	0.3366	0.0211
					Creative Thinking and Problem Solving	0.4822	0.0302
					Interdisciplinary Thinking and Associations	0.1812	0.0114

		Learning Strategies	0.6731	0.1288	Summarization and Induction Ability	0.5143	0.0663
					Self-test and Rhetorical Questions	0.4857	0.0626
Emotional Engagement	0.2407	Self Worth	0.5279	0.127	Identity	0.7606	0.0788
					Sense of Belonging	0.2394	0.0305
		Emotional Experience	0.3426	0.0825	Sense of Accomplishment	0.2329	0.0193
					Interest	0.7671	0.0633
		Emotional Regulation	0.1295	0.0312	Cognitive Reappraisal	0.2125	0.0067
					Emotional Transfer	0.7875	0.0246

According to the analysis results of weight values, the importance ranking of the first-level indicators can be determined as follows: " behavioral engagement ","emotional engagement " and " Cognitive engagement ".In terms of secondary indicators, the top five in descending order are "focus","self-monitoring","learning strategies "," sense of identity " and " interaction ". As for the third-level indicators, the top five include "use of learning tools "," completion of classroom assignments","self-identity","classroom behavioral performance" and " cognitive strategies".In addition,relatively low weight values are assigned to"learning motivation adjustment","goal setting ","class attendance rate","overcoming difficulties " and " learning resource management" , which shows the importance of these five third-level indicators Sex is less prominent.

4.2.3 To Identify Blended Learning Engagement Evaluation System for University in China

The study will randomly select 5 universities in Sichuan Province, China, and evaluate 100 teachers. Questionnaire V is distributed to experts, and the expert evaluation results are as follows:

Table 4.18 Expert opinion results

Level 1	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Behavioral Engagement (0.568)	95.0	4.0	1.0
Cognitive Engagement （0.1914）	90.0	8.0	2.0
Emotional Engagement （0.2407）	87.0	10.0	3.0

Table 4.18 Expert opinion results(Cout.)

Level 2	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Participate(0.0787)	93.0	7.0	0.0
Focus（0.1949）	93.0	6.0	1.0
Interaction（0.0838）	92.0	5.0	3.0
Persistence（0.0684）	90.0	8.0	2.0
Self-monitoring（0.1422）	93.0	7.0	0.0
Depth of thinking（0.0626）	93.0	4.0	3.0
Learning Strategies(0.1288)	89.0	7.0	4.0
Self Worth(0.1270)	95.0	3.0	2.0
Emotional Experience(0.0825)	95.0	2.0	3.0
Emotion Regulation(0.0312)	92.0	6.0	2.0

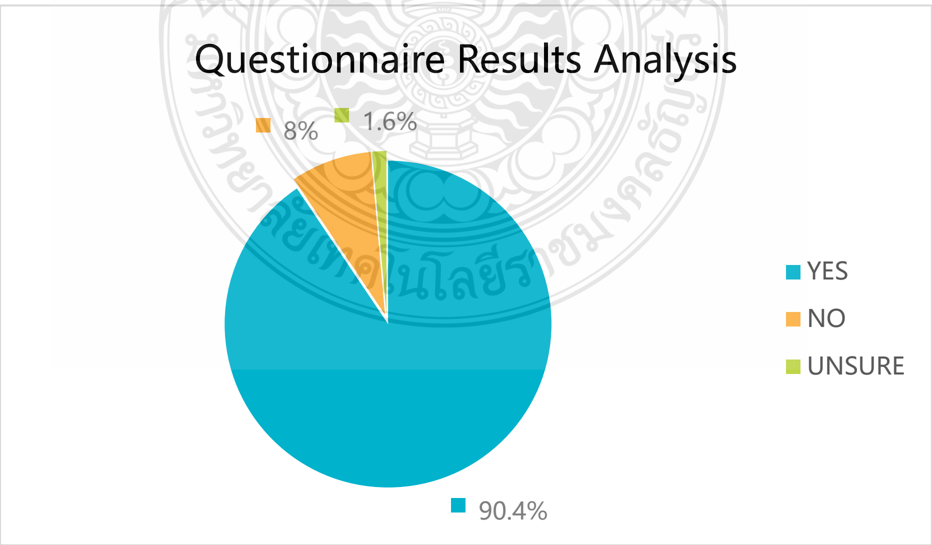
Table 4.18 Expert opinion results(Cout.)

Level 3	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Number of online platform logins(0.0307)	95.0	5.0	0.0
Online platform task completion(0.0230)	93.0	6.0	1.0
Frequency of answering questions in class(0.0153)	96.0	4.0	0.0
classroom attendance(0.0097)	96.0	4.0	0.0
The amount of video played per unit time(0.0264)	95.0	4.0	1.0
Amount of classroom tasks completed(0.0976)	94.0	5.0	1.0
Classroom performance(0.0709)	86.0	11.0	0.0
Discussion popularity on online platforms(0.0391)	85.0	11.0	2.0
Peer Reviews and Feedback(0.0263)	88.0	8.0	3.0
Teacher-student interaction(0.0184)	87.0	10.0	3.0
overcome difficulties(0.0115)	88.0	8.0	3.0
Online Task Persistence(0.0362)	89.0	9.0	0.0
Maintaining a high level of engagement in the classroom(0.0207)	86.0	14.0	0.0
Clarify goals and requirements(0.0389)	83.0	15.0	2.0

Self-evaluation and reflection(0.0214)	92.0	8.0	0.0
Learning environment adjustment(0.0818)	93.0	5.0	2.0
Logic and Critical Thinking(0.0211)	84.0	15.0	1.0
Creative Thinking and Problem Solving(0.0302)	91.0	9.0	0.0
Interdisciplinary Thinking and Associations(0.0113)	90.0	9.0	1.0
Summarization and Induction Ability(0.0662)	91.0	7.0	1.0
Self-test and Rhetorical Questions(0.0626)	91.0	7.0	1.0
Identity(0.0966)	90.0	9.0	1.0
Sense of Belonging(0.0304)	90.0	9.0	1.0
Sense of Accomplishment(0.0192)	84.0	15.0	1.0
Interest(0.0633)	86.0	12.0	2.0
Cognitive Reappraisal(0.0066)	88.0	10.0	2.0
Emotional Transfer(0.0245)	87.0	12.0	1.0

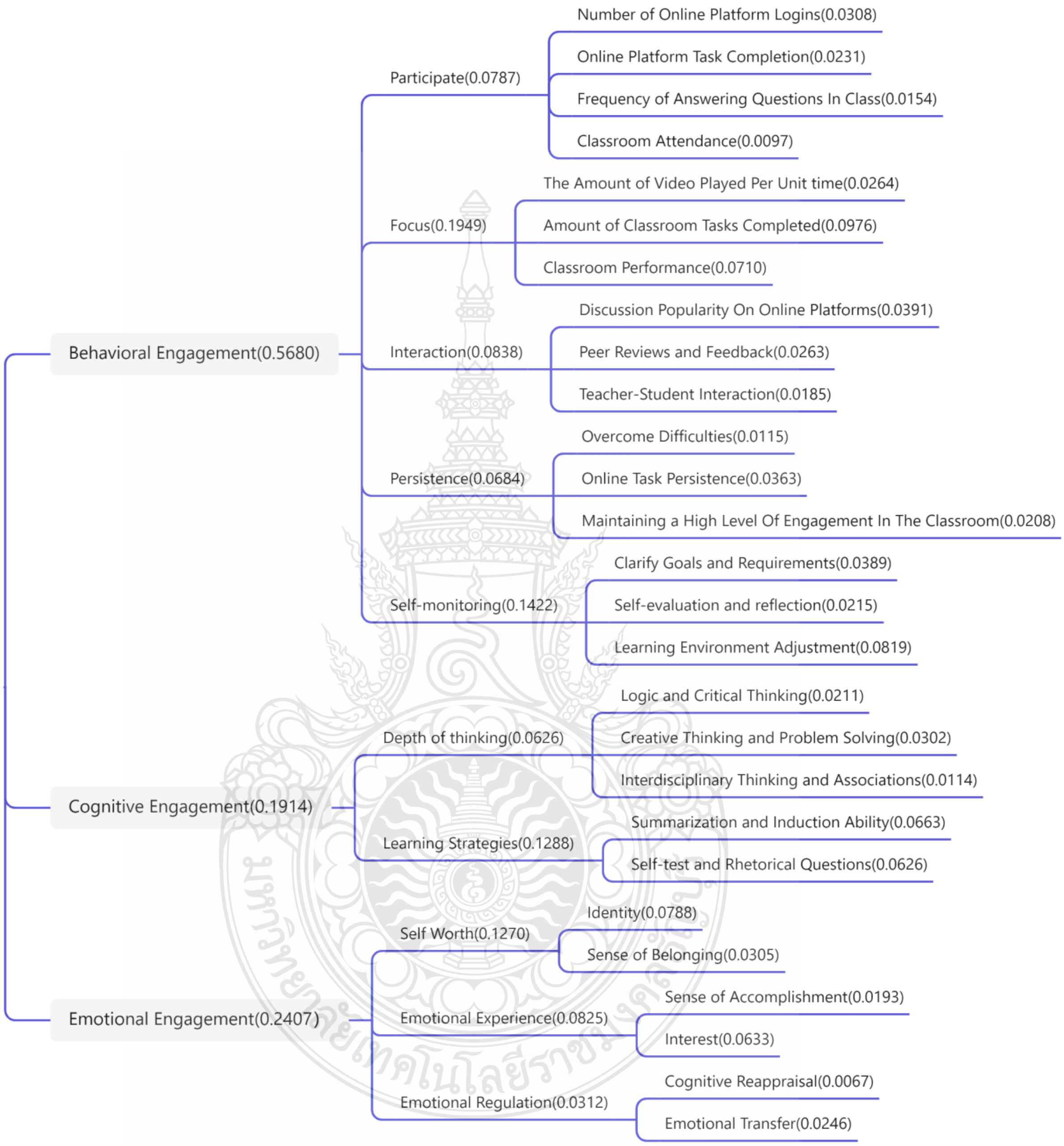
Based on the evaluation criteria gathered from the last three rounds, Questionnaire III was developed to assess instructors' perspectives on specific assessment indicators. We chose five universities and conducted a random survey of 100 teachers in Sichuan province, China, to evaluate these indicators. The questionnaire contained a total of 40 indicator items with a 90.4% yes response rate, an 8.0% no response rate, and a 1.6% unsure response rate.

Figure 4.1Questionnaire Evaluation Results from 100 University Faculty Members



Based on the findings, it is evident that most teachers support this assessment system. Consequently, we can develop a thorough evaluation framework as outlined below:

Figure 4.2 Blended Learning Evaluation System for University in China


Behavioral Engagement(0.5680)
Participate(0.0787)
Number of Online Platform Logins(0.0308)
Online Platform Task Completion(0.0231)
Frequency of Answering Questions In Class(0.0154)
Classroom Attendance(0.0097)
Focus(0.1949)
The Amount of Video Played Per Unit time(0.0264)
Amount of Classroom Tasks Completed(0.0976)
Classroom Performance(0.0710)
Interaction(0.0838)
Discussion Popularity On Online Platforms(0.0391)
Peer Reviews and Feedback(0.0263)
Teacher-Student Interaction(0.0185)
Persistence(0.0684)
Overcome Difficulties(0.0115)
Online Task Persistence(0.0363)
Maintaining a High Level Of Engagement In The Classroom(0.0208)
Self-monitoring(0.1422)
Clarify Goals and Requirements(0.0389)
Self-evaluation and reflection(0.0215)
Learning Environment Adjustment(0.0819)
Cognitive Engagement(0.1914)
Depth of thinking(0.0626)
Logic and Critical Thinking(0.0211)
Creative Thinking and Problem Solving(0.0302)
Interdisciplinary Thinking and Associations(0.0114)
Learning Strategies(0.1288)
Summarization and Induction Ability(0.0663)
Self-test and Rhetorical Questions(0.0626)
Emotional Engagement(0.2407)
Self Worth(0.1270)
Identity(0.0788)
Sense of Belonging(0.0305)
Emotional Experience(0.0825)
Sense of Accomplishment(0.0193)
Interest(0.0633)
Emotional Regulation(0.0312)
Cognitive Reappraisal(0.0067)
Emotional Transfer(0.0246)

4.3 Application of evaluation system for engagement in blended learning in colleges and universities

To evaluate the adequacy of the developed blended learning engagement evaluation index system, this research will examine the learning engagement at Sichuan University of Science and Engineering. Initially, it delineates the features of blended learning before administering relevant surveys to instructors. Subsequently, fuzzy comprehensive evaluation is utilized to compute and scrutinize collected data. The resulting assessment findings are examined for identified issues and underlying reasons, followed by suggestions for remedial actions.

4.3.1 Selection of research objects

Sichuan University of Science and Engineering comprises 19 academic faculties, serving a student body of 39,325 undergraduates with the support of 1,928 faculty members. Among them are 518 instructors with diverse teaching backgrounds. A subset of 226 such teachers were surveyed for their expertise in utilizing hybrid teaching approaches. Additionally, these educators employ various methods including online platform data analysis, classroom assessments, and student interviews to effectively evaluate and provide feedback on students' performance.

4.3.2 Research results

The developed blended learning participation evaluation index system is a method of combined qualitative and quantitative assessment. When calculating the evaluation results, it is not possible to calculate from a single perspective or method. By combining fuzzy comprehensive evaluation, it is possible to quantify qualitative indicators and classify them reasonably, hence adopting the fuzzy comprehensive evaluation method to calculate the evaluation results.

1. Evaluation index set

Three first-level indicators in this study , so the first-level indicator set U is established as {U1 , U2 , U3} , U1 represents row is investment, U2 represents Cognitive engagement, U3 represents emotional engagement, and U refers to a fuzzy phenomenon evaluated in the study. According to the above method, the second-level index set and the third-level index set can be obtained, as shown in the following table:

Table 4.19 Evaluation index set

Level 1 Set	Level 1	Corresponding Indicator Name
U	U1	Behavioral Engagement
	U3	Cognitive Engagement
	U3	Emotional Engagement

Table 4.19 Evaluation index set(Cout.)

Level 2 Set	Level 2	Corresponding Indicator Name
U1	U11	Participate
	U12	Focus
	U13	Interaction
	U14	Persistence

	U15	Self-monitoring
U2	U21	Depth of thinking
	U22	Learning Strategies
U3	U31	Self Worth
	U32	Emotional Experience
	U33	Emotion Regulation

Table 4.19 Evaluation index set(Cout.)

Level 3 Set	Level 3	Corresponding Indicator Name
U11	U111	Number of online platform logins
	U112	Online platform task completion
	U113	Frequency of answering questions in class
	U114	classroom attendance
U12	U121	The amount of video played per unit time
	U122	Amount of classroom tasks completed
	U123	Classroom performance
U13	U131	Discussion popularity on online platforms
	U132	Peer Reviews and Feedback
	U133	Teacher-student interaction
U14	U141	Overcome difficulties
	U142	Online Task Persistence
	U143	Maintaining a high level of engagement in the classroom
U15	U151	Clarify goals and requirements
	U152	Self-evaluation and reflection
	U153	Learning environment adjustment
U21	U211	Logic and Critical Thinking
	U212	Creative Thinking and Problem Solving
	U213	Interdisciplinary Thinking and Associations
U22	U221	Summarization and Induction Ability
	U222	Self-test and Rhetorical Questions
U31	U311	Identity
	U312	Sense of Belonging
U32	U321	Sense of Accomplishment
	U322	Interest

U33	U331	Cognitive Reappraisal
	U332	Emotional Transfer

2. Collection of comments from questionnaire survey judges

In this investigation, the evaluation scale included ratings of 95 points for "very satisfied," 82.5 points for "satisfied," 67.5 points for "average," 50 points for "dissatisfied," and 20 points for "very dissatisfied." It is worth noting that V={20 , 50 , 67.5 , 82.5 ,97}.

3. Calculate the membership degree of indicator items

Questionnaire VI was distributed to all faculty members at Sichuan University of Science and Engineering, resulting in a total of 226 surveys being dispersed. From the favorable feedback received, we obtained 210 usable surveys, achieving an impressive retrieval rate of 92.9%.

Table 4.20 Questionnaire results

Level 1 indicators	Level 2 indicators	Level 3 indicators	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
U1	U11	U111	1	15	81	90	23
		U112	0	16	79	95	20
		U113	0	14	98	86	12
		U114	3	12	92	85	18
	U12	U121	1	18	84	93	14
		U122	3	11	82	97	17
		U123	2	24	75	89	20
	U13	U131	3	23	73	90	21
		U132	2	13	91	82	22
		U133	0	21	80	91	18
	U14	U141	3	12	82	96	17
		U142	3	13	80	95	19
		U143	0	17	78	97	18
	U15	U151	0	14	101	79	16
		U152	2	20	75	94	19
		U153	1	15	72	101	21
U2	U21	U211	0	14	98	81	17
		U212	1	18	92	85	14
		U213	3	16	85	94	12

	U22	U221	2	19	78	100	11
		U222	2	24	88	84	12
U3	U31	U311	1	12	96	85	16
		U312	1	19	86	92	12
	U32	U321	3	17	90	86	14
		U322	1	22	91	83	13
	U33	U331	2	11	98	89	10
		U332	3	21	82	98	6

Based on the questionnaire results, we calculated the membership degree of the indicator items. To illustrate this process, we take the calculation of the membership degree of indicator item U111 as an example. In terms of different evaluation levels, U111 received evaluations as follows: 1 person was very dissatisfied, 15 people were dissatisfied, 81 people were average, 90 people were in line, and 23 people were completely in line . The total number of evaluators is 210. Based on these data, we calculated the membership degrees of U111 at each level, which are 1/210,15/210,81/210,90/210,23/210,that is,0.005,0.071,0.386,0.429, 0.110respectively.Finally, based on the calculation of the membership degrees of all indicator items, we obtained the fuzzy relationship matrix of the indicator system, as shown below:

Table 4.21Fuzzy relationship matrix of blended learning engagement evaluation system

Level 1 indicators	Level 2 indicators	Level 3 indicators	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
U1	U11	U111	0.005	0.071	0.386	0.429	0.110
		U112	0.000	0.076	0.376	0.452	0.095
		U113	0.000	0.067	0.467	0.410	0.057
		U114	0.014	0.057	0.438	0.405	0.086
	U12	U121	0.005	0.086	0.400	0.443	0.067
		U122	0.014	0.052	0.390	0.462	0.081
		U123	0.010	0.114	0.357	0.424	0.095
	U13	U131	0.014	0.110	0.348	0.429	0.100
		U132	0.010	0.062	0.433	0.390	0.105
		U133	0	0.100	0.381	0.433	0.086
	U14	U141	0	0.057	0.390	0.457	0.081
		U142	0.014	0.062	0.381	0.452	0.090

		U143	0	0.081	0.371	0.462	0.086
	U15	U151	0.000	0.067	0.481	0.376	0.076
		U152	0.010	0.095	0.357	0.448	0.090
		U153	0.005	0.071	0.343	0.481	0.100
U2	U21	U211	0.000	0.067	0.467	0.386	0.081
		U212	0.005	0.086	0.438	0.405	0.067
		U213	0.014	0.076	0.405	0.448	0.057
	U22	U221	0.010	0.090	0.371	0.476	0.052
		U222	0.010	0.114	0.419	0.400	0.057
U3	U31	U311	0.005	0.057	0.457	0.405	0.076
		U312	0.005	0.090	0.410	0.438	0.057
	U32	U322	0	0.081	0.429	0.410	0.067
		U323	0.005	0.105	0.433	0.395	0.062
	U33	U331	0.010	0.052	0.467	0.424	0.048
		U332	0.014	0.100	0.390	0.467	0.029

3.Fuzzy comprehensive evaluation model

Based on the index weight and the membership degree of each index, we can construct a fuzzy relationship matrix and further calculate the investment level of Sichuan University of Science and Engineering students in blended learning. The following are the specific steps for calculation:

Fuzzy comprehensive evaluation of three-level indicators lists the corresponding weight vectors: A_{11} = (0.3903, 0.2922, 0.1944, 0.1231), A_{12} = (0.1353, 0.5007, 0.3640), A_{13} = (0.4664, 0.3136, 0.2200), A_{14} = (0.1676, 0.5292, 0.3032), A_{15} = (0.2736, 0.1508, 0.5756), A_{21} = (0.3366, 0.4822, 0.1812), A_{22} = (0.5143, 0.4857), A_{31} = (0.7606, 0.23 94), A_{32} = (0.2329, 0.7671), A_{33} = (0.2125, 0.7875).

$$R_{11} = \begin{bmatrix} 0.005 & 0.071 & 0.386 & 0.429 & 0.110 \\ 0 & 0.076 & 0.376 & 0.452 & 0.095 \\ 0 & 0.067 & 0.467 & 0.410 & 0.057 \\ 0.014 & 0.057 & 0.438 & 0.405 & 0.086 \end{bmatrix}$$

$$R_{12} = \begin{bmatrix} 0.005 & 0.086 & 0.400 & 0.443 & 0.067 \\ 0.014 & 0.052 & 0.390 & 0.462 & 0.081 \\ 0.010 & 0.114 & 0.357 & 0.424 & 0.095 \end{bmatrix}$$

$$R_{13} = \begin{bmatrix} 0.014 & 0.110 & 0.348 & 0.429 & 0.100 \\ 0.010 & 0.062 & 0.433 & 0.390 & 0.105 \\ 0 & 0.100 & 0.381 & 0.443 & 0.086 \end{bmatrix}$$

$$R_{14}=\begin{bmatrix} 0 & 0.057 & 0.390 & 0.457 & 0.081 \\ 0.014 & 0.062 & 0.381 & 0.452 & 0.090 \\ 0 & 0.081 & 0.371 & 0.462 & 0.086 \end{bmatrix}$$

$$R_{15}=\begin{bmatrix} 0 & 0.067 & 0.481 & 0.376 & 0.076 \\ 0.010 & 0.095 & 0.357 & 0.448 & 0.090 \\ 0.005 & 0.071 & 0.343 & 0.481 & 0.100 \end{bmatrix}$$

$$R_{21}=\begin{bmatrix} 0 & 0.067 & 0.467 & 0.386 & 0.081 \\ 0.005 & 0.086 & 0.438 & 0.405 & 0.067 \\ 0.014 & 0.076 & 0.405 & 0.448 & 0.057 \end{bmatrix}$$

$$R_{22}=\begin{bmatrix} 0.010 & 0.090 & 0.371 & 0.476 & 0.052 \\ 0.010 & 0.114 & 0.419 & 0.400 & 0.057 \end{bmatrix}$$

$$R_{31}=\begin{bmatrix} 0.005 & 0.057 & 0.457 & 0.405 & 0.076 \\ 0.005 & 0.090 & 0.410 & 0.438 & 0.057 \end{bmatrix}$$

$$R_{32}=\begin{bmatrix} 0 & 0.081 & 0.429 & 0.410 & 0.067 \\ 0.005 & 0.105 & 0.433 & 0.395 & 0.062 \end{bmatrix}$$

$$R_{33}=\begin{bmatrix} 0.010 & 0.052 & 0.467 & 0.424 & 0.048 \\ 0.014 & 0.100 & 0.390 & 0.467 & 0.029 \end{bmatrix}$$

$B_{11}=A_{11}\times R_{11}$

$$=(0.3903 , 0.2922 , 0.1944 , 0.1231)\begin{bmatrix} 0.005 & 0.071 & 0.386 & 0.429 & 0.110 \\ 0 & 0.076 & 0.376 & 0.452 & 0.095 \\ 0 & 0.067 & 0.467 & 0.410 & 0.057 \\ 0.014 & 0.057 & 0.438 & 0.405 & 0.086 \end{bmatrix}$$

=(0.0037,0.0700,0.4052,0.4291,0.0924)

B_{12}=(0.0113,0.0792,0.3793,0.4456,0.0842)

B_{13}=(0.0097,0.0927,0.3819,0.4176,0.0985)

B_{14}=(0.0074,0.0669,0.3795,0.4559,0.0873)

B_{15}=(0.0044,0.0735,0.3829,0.4473,0.0919)

B_{21}=(0.0049,0.0778,0.4418 , 0.4064,0.0699)

B_{22}=(0.0100,0.1017,0.3943,0.4391,0.0544)

B_{31}=(0.0050,0.0649,0.4457,0.4129,0.0715)

B_{32}=(0.0038,0.0994,0.4321,0.3985,0.0632)

B_{33}=(0.0132,0.0898,0.4064,0.4579,0.0330)

Second-level fuzzy comprehensive evaluation lists the corresponding weight vectors: A_1 =(0.1386,0.3431,0.1476,0.1205,0.2503), A_2 =(0.3269,0.6731) ,A_3 =(0.5279,0.3426,0.1295).

$$R_1 = \begin{bmatrix} 0.0037 & 0.0700 & 0.4052 & 0.4291 & 0.0924 \\ 0.0113 & 0.0792 & 0.3793 & 0.4456 & 0.0842 \\ 0.0097 & 0.0927 & 0.3819 & 0.4176 & 0.0985 \\ 0.0074 & 0.0669 & 0.3795 & 0.4559 & 0.0873 \\ 0.0044 & 0.0735 & 0.3829 & 0.4473 & 0.0919 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.0049 & 0.0778 & 0.4418 & 0.4064 & 0.0699 \\ 0.0100 & 0.1017 & 0.3943 & 0.4391 & 0.0544 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.0050 & 0.0649 & 0.4457 & 0.4129 & 0.0715 \\ 0.0038 & 0.0994 & 0.4321 & 0.3985 & 0.0632 \\ 0.0132 & 0.0898 & 0.4064 & 0.4579 & 0.0330 \end{bmatrix}$$

$B_1 = A_1 \times R_1$

$$=(0.1386,0.3431,0.1476,0.1205,0.2503)\begin{bmatrix} 0.0037 & 0.0700 & 0.4052 & 0.4291 & 0.0924 \\ 0.0113 & 0.0792 & 0.3793 & 0.4456 & 0.0842 \\ 0.0097 & 0.0927 & 0.3819 & 0.4176 & 0.0985 \\ 0.0074 & 0.0669 & 0.3795 & 0.4559 & 0.0873 \\ 0.0044 & 0.0735 & 0.3829 & 0.4473 & 0.0919 \end{bmatrix}$$

$=(0.0078,0.0770,0.3842,0.4409,0.0898)$

$B_2 =(0.0083,0.0939,0.4098,0.4284,0.0595)$

$B_3 =(0.0057,0.0799,0.4360,0.4138,0.0637)$

First-level fuzzy comprehensive rating, corresponding weight vector: A=(0.568, 0.1914, 0.2407)

$$B=A\times R= (0.568,0.1914,0.2407)\begin{bmatrix} 0.0078 & 0.0770 & 0.3842 & 0.4409 & 0.0898 \\ 0.0083 & 0.0939 & 0.4098 & 0.4284 & 0.0595 \\ 0.0057 & 0.0799 & 0.4360 & 0.4138 & 0.0637 \end{bmatrix}$$

$=(0.0074,0.0809,0.4016,0.4320,0.0777)$

4. results and analysis

Through the fuzzy comprehensive evaluation of the indicator system, we can calculate the input indicator scores of students at Sichuan University of Science and Engineering in blended learning. This score will comprehensively consider the weight and affiliation of each indicator to reflect the overall level of student engagement. B=(0.0007,0.0110,0.0501,0.1389,0.0109), comment set V={20 , 50 , 67.5 , 82.5 , 95} , so the total learning engagement evaluation score of Sichuan University of Science and Engineering is: α=B*V=0.0074 *20+0.0809*50*0.4016*67.5+0.4320*82.5+0.0777*95=74.32

Based on the aforementioned data, it is evident that students at Sichuan University of Science and Engineering demonstrate a significant level of commitment to blended learning, at a moderate level. However, for a more comprehensive insight into students' engagement in learning, further examination of individual item scores within the primary indicators is essential. Through thorough analysis of these scores, areas with higher investment can be identified as well as those requiring additional attention. This detailed assessment enables educational institutions and educators to gain better insight into student needs and develop appropriate educational and supportive measures to enhance both learning engagement and effectiveness. The findings from this extensive evaluation serve as valuable guidance for enhancing student participation in blended learning. To delve deeper into specific influencing factors, we have computed the scores for individual items within the primary indicator of learning engagement; these results are presented in the table below:

Table 4.22 Scores for Primary Indicators

Level 1	Score
Behavioral Engagement	74.84
Cognitive Engagement	73.52
Emotional Engagement	73.73

After analyzing the assessment form, it becomes evident that college students' performance is most prominent in behavioral engagement, followed by emotional engagement. However, cognitive engagement scores are relatively low and may significantly impact student involvement in learning. To gain a deeper insight into students' learning engagement, further analysis of secondary and tertiary indicators is necessary. This detailed examination will pinpoint specific areas requiring improvement to enhance student learning experiences and outcomes.The score calculation results for the secondary and tertiary indicators are presented below, offering a more in-depth understanding to assist schools and educators in making specific decisions and implementing enhancement strategies. Refer to the table for details:

Table 4.23 Scores for Behavioral Engagement

Level 2	Score	Level 3	Score
Participate	75.10	Number of online platform logins	75.55
		Online platform task completion	75.50
		Frequency of answering questions in class	74.11
		Classroom attendance	74.28
Focus	74.55	The amount of video played per unit time	74.31
		Amount of classroom tasks completed	75.02
		Classroom performance	74.00
Interaction	74.42	Discussion popularity on online platforms	74.16
		Peer Reviews and Feedback	74.68
		Teacher-student interaction	74.61
Persistence	75.01	Overcome difficulties	74.57
		Online Task Persistence	74.94
		Maintaining a High Level of Engagement in the Classroom	75.38

Self-monitoring	75.24	Clarify goals and requirements	74.06
		Self-evaluation and reflection	74.56
		Learning environment adjustment	75.99

Based on the data table analysis, students scored lower in study concentration and student interaction indicators at 74.55 and 74.42 respectively. This suggests that students may encounter difficulties in blended learning. Specifically, lower scores for study concentration suggest that students are prone to distractions during their learning process. Moreover, the relatively low scores for student interaction in online courses may indicate a need for increased stimulation and support to foster interaction and collaboration among students.Classroom task fulfillment demonstrates relatively high scores, indicating that under traditional classroom settings, teacher guidance and oversight positively influence students' completion of tasks. This underscores the significant role of teachers in blended learning. On the other hand, video playback duration scores relatively low, particularly in online courses. This suggests that students may be prone to distractions during online learning without teacher supervision. Furthermore, the score for the third-level interaction indicator is also relatively low, signifying that students may lack willingness to engage, communicate and participate in discussions during their learning process. It appears that additional encouragement and support might be necessary in this aspect.The participation and self-regulation metrics both received high scores of 75.1 and 75.24, suggesting that college students demonstrate a mature attitude towards learning engagement and self-discipline, along with the ability to self-monitor effectively. This bodes well for blended learning, as indicated by the relatively high scores in third-level indicators such as online platform logins and task completion; these reflect strong motivation among college students to engage with online learning platforms, potentially surpassing their willingness to participate in traditional classroom settings. Moreover, the higher score in learning environment adjustment points toward student satisfaction with the overall academic experience including teaching support, flexibility offered by educators alongside environmental suitability for effective learning.The combined information offers valuable perspectives on student involvement in hybrid learning. Educational institutions and teachers can use these findings to implement strategies that enhance the learning experience, academic achievements, as well as encourage greater interaction and participation among students. This focused effort aims to boost both student learning outcomes and satisfaction with their educational experiences.

Table 4.24 Scores for Cognitive Engagement

Level 2	Score	Level 3	Score
Depth of thinking	73.98	Logic and Critical Thinking	74.41
		Creative Thinking and Problem Solving	73.74
		Interdisciplinary Thinking and Associations	73.79
Learning Strategies	73.29	Summarization and Induction Ability	73.95
		Self-test and Rhetorical Questions	72.60

The table data suggests that students showed lower performance in deep thinking and learning strategies. This points to a need for additional assistance and training to enhance their analytical, synthetic, and critical thinking abilities. Effective deep thinking is crucial for tackling complex problems and excelling in advanced academic tasks, so educational institutions should consider promoting the development of these skills among students. Furthermore, the relatively poor scores in learning strategies indicate challenges with creating study plans, time management during studying, and utilizing effective study methods. Schools and educators can offer more support and resources to aid students in enhancing the effectiveness and quality of their learning techniques.Although the score of deep thinking is relatively low, in the third-level indicator, the score of logical thinking ability is higher. This shows that students have certain logical thinking and problem-solving abilities, which is a positive sign. Schools can further encourage and develop this ability to help students better cope with academic challenges. Self-test and rhetorical questions scored the lowest, which may indicate some deficiencies in students' self-assessment and active learning. Schools can consider providing more self-assessment tools and training to help students improve their self-monitoring and reflective skills, thereby improving learning outcomes.Taken collectively, these insights offer educational institutions and teachers valuable data on student learning tendencies and approaches. Implementing specific interventions to tackle these concerns can enhance students' academic performance and educational journey, equipping them with improved abilities to handle academic hurdles.

Table 4.25 Scores for Emotional Engagement

Level 2	Score	Level 3	Score
Self Worth	74.29	Identity	74.43
		Sense of Belonging	73.83
Emotional Experience	73.21	Sense of Accomplishment	73.20
		Interest	73.06
Emotional Regulation	73.10	Cognitive Reappraisal	73.86
		Emotional Transfer	72.89

The table indicates that the self-worth score for the secondary indicator is relatively high, suggesting that students have a positive perception of themselves, exhibit confidence, and may be more inclined to pursue their goals. Among its corresponding three-level indicators, sense of identity has achieved the highest score, indicating a positive emotional experience in learning and an inclination to invest time and energy into learning. The lowest-rated secondary indicator is emotional regulation, demonstrating that students experience challenges in managing emotions and coping with stress - factors which could impact their learning outcomes and overall well-being. Offering emotional support and training can assist them in better handling emotional challenges while enhancing their regulation skills. In addition, its corresponding third-level emotion transfer score is also at its lowest point; this implies that college students might encounter emotional distress or fatigue during the educational process leading to feelings of anxiety, frustration, and stress - making it difficult for them to convert negative emotions into positive motivation for learning.

In summary, Sichuan University of Science and Engineering students performed well in blended learning engagement scores, and students performed differently under different indicators, which provides useful information for further improving educational strategies and providing targeted support. Students perform better in terms of behavioral engagement and self-worth, which may mean they perform well in actively participating in learning activities and maintaining self-confidence. This is a reflection of a positive learning attitude. Cognitive engagement was relatively low, which may indicate students' challenges with deep thinking and learning strategies. This can serve as a focus area for educational institutions and educators to improve teaching methods and learning support. In terms of emotional engagement, lower scores on emotion regulation may reflect students' challenges in emotion management. Emotional support and training need to be provided.

4.3.3 Countermeasures and suggestions

Blended learning refers to an educational approach that integrates components of conventional in-person teaching with online education, offering students a more adaptable method of learning. Nevertheless, there are various challenges related to student engagement in blended learning encompassing different facets involving students, educators, and institutions. In light of the aforementioned evaluation outcomes, we will examine these challenges and propose strategies and recommendations for students, educators, and institutions to address the issue of student engagement within blended learning.

1. Self-management and planning abilities: Blended learning requires students to have stronger self-management and planning abilities because they need to effectively arrange learning time and tasks . Students can use time management tools and apps to help them plan their studies and ensure tasks are completed on time.
2. Positive learning attitude: Students should develop a positive learning attitude and regard blended learning as an opportunity to learn and grow rather than a burden. They can set clear learning goals, understand why they want to learn, and maintain a passion for knowledge.
3. Independent learning skills: Blended learning encourages students to learn independently, so students need to develop independent learning skills, including information retrieval, reading and research abilities . They can learn to use online resources effectively, such as library databases and academic search engines.
4. Interaction and engagement: Although blended learning focuses on online learning, interaction and engagement are still crucial. Students are expected to actively participate in online discussions, collaborative projects, and virtual meetings. They can proactively ask questions, share opinions, and actively interact with classmates to promote in-depth learning.
5. Emotional management and self-care : Blended learning can bring with it a level of stress and anxiety, so students need to learn emotional management and self-care. Regular exercise, meditation and socializing with friends can help them maintain their emotional health. If you are feeling emotionally distressed, it is crucial to seek prompt mental health support.

Countermeasures and suggestions for teachers:

1. Create a rich online learning experience: Teachers should make full use of online education tools to create a rich and diverse online learning experience. This includes designing interactive course content, making full use of multimedia resources, organizing virtual experiments and simulations, and providing online discussion and interactive environments.

2. Personalized guidance and support: Teachers can better understand each student’s learning needs and level and provide personalized guidance and support. Through one-on-one meetings, email, and online office hours, faculty are available to answer student questions, provide timely feedback, and help them solve academic challenges.

3. Encourage collaboration and interaction: Although blended learning emphasizes independent learning, teachers can still encourage collaboration and interaction among

3. Encourage innovation and the applicationstudents. Organize online group projects, collaborative assignments, and virtual team meetings to promote collaboration and communication among students.

4. Provide clear learning objectives and feedback: Teachers should clearly communicate learning objectives and provide clear assessment criteria. Provide timely feedback to help students understand their academic progress and guide them in improving their learning strategies.

5. Emotional support and understanding : Teachers should understand the emotional challenges students may encounter in blended learning and provide support and understanding. Build trusting relationships, encourage students to share emotional distress, and provide emotional support and guidance.

School strategies and suggestions

1. Provide online learning support services: Schools should provide a wide range of online learning support services, including online academic consultation, study skills training and online mental health support. These services can help students better adapt to the blended learning model.

2. Teacher training and development: Schools can provide teacher training and development programs to help teachers master online education tools and teaching strategies. Training can also include emotional support techniques to help teachers better respond to students' emotional needs.

of educational technology: Schools should encourage teachers to innovate teaching methods and make full use of educational technology to enrich the learning experience. Provide support and resources to help teachers design innovative blended learning courses.

4. Regular evaluation and improvement: Schools should regularly evaluate the effectiveness of blended learning and make improvements based on the evaluation results. This includes improvements in curriculum design, support services and school policies to meet student learning needs.

5. Social interaction and student participation: Schools can encourage social interaction and student participation , and organize online social activities, academic seminars, and student organizations to promote communication and cooperation among students. Provide support and resources to help students participate in extracurricular activities and volunteer work.

Taken together, the learning engagement problem of blended learning can be solved through the joint efforts of students, teachers and schools. Students need to develop self-management, independent learning and emotion management skills. Teachers can create rich online learning experiences, provide personalized guidance and support, and encourage interaction and collaboration. Schools can provide a wide range of online learning support services, teacher training and development, encourage innovation and regular assessment to meet the learning needs of students in a blended learning environment. The blended learning model provides students with greater flexibility and choice. Through the implementation of the above countermeasures and suggestions, it can help students better engage in learning and improve academic performance

CHAPTER 5
CONCLUSION, DISCUSSION AND RECOMMENDATION

This chapter encompasses a comprehensive overview of the research, including summaries, discussions, conclusions, limitations, and contributions. It culminates in the establishment of a novel assessment model for higher education blended learning implementation, which integrates various key indicators and elements into a cohesive framework.

5.1 Conclusion
5.2 Discussion
5.3 Limitations
5.4 Contributions

5.1 Conclusion

5.1.1 To synthesize the Various indicators of the Blended Learning Engagement Evaluation System. Through conducting expert interviews and surveys, we have identified factors associated with learning engagement. Based on insights gathered from expert interviews and existing theories on participation in blended learning (behaviour, cognition, and emotion), we have developed indicators to assess blended learning engagement. Following three rounds of expert surveys and using the Analytic Hierarchy Process for weighting, we have established the components of an evaluation system for participation in higher education institutions. Employing the Delphi method, initial brainstorming sessions were conducted with experts after the first round of surveys. A preliminary evaluation framework was then developed based on questionnaire responses and expert opinions. Subsequent rounds involved Likert scale surveys to gather expert evaluation data; this process led to adjustments and deletions of indicators based on feedback from experts. In the fourth round, 17 experts were asked to respond "Yes" or "No" in a questionnaire to obtain final confirmation of their opinions.

Table 5.1 Blended learning engagement in the indicators elements and weights of the evaluation system

Level 1	**Weight**	**Level 2**	**Weight**	**Composite Weight**	**Level 3**	**Weight**	**Composite Weight**
Behavioural Engagement	0.5680	Participate	0.1386	0.0787	Number of online platform logins	0.3903	0.0308
					Online platform task completion	0.2922	0.0231
					Frequency of answering questions in class	0.1944	0.0154
					classroom attendance	0.1231	0.0097
		Focus	0.3431	0.1949	The amount of video played per unit time	0.1353	0.0264
					Amount of classroom tasks completed	0.5007	0.0976
					Classroom performance	0.3640	0.0710
		Interaction	0.1476	0.0838	Discussion popularity on online platforms	0.4664	0.0391
					Peer Reviews and Feedback	0.3136	0.0263

Table 5.1 Blended learning engagement in the indicators elements and weights of the evaluation system (Cont.)

Level 1	**Weight**	**Level 2**	**Weight**	**Composite Weight**	**Level 3**	**Weight**	**Composite Weight**
					Teacher-student interaction	0.2200	0.0185
		Persistence	0.1205	0.0684	overcome difficulties	0.1676	0.0115
					Online Task Persistence	0.5292	0.0363
					Maintaining a high level of engagement in the classroom	0.3032	0.0208
		Self-monitoring	0.2503	0.1422	Clarify goals and requirements	0.2736	0.0389
					Self-evaluation and reflection	0.1508	0.0215
					Learning environment adjustment	0.5756	0.0819
Cognitive Engagement	0.1914	Depth of thinking	0.3269	0.0626	Logic and Critical Thinking	0.3366	0.0211
					Creative Thinking and Problem Solving	0.4822	0.0302

Table 5.1 Blended learning engagement in the indicators elements and weights of the evaluation system (Cont.)

Level 1	**Weight**	**Level 2**	**Weight**	**Composite Weight**	**Level 3**	**Weight**	**Composite Weight**
					Interdisciplinary Thinking and Associations	0.1812	0.0114
		Learning Strategies	0.6731	0.1288	Summarization and Induction Ability	0.5143	0.0663
					Self-test and Rhetorical Questions	0.4857	0.0626
Emotional Engagement	0.2407	Self-Worth	0.5279	0.127	Identity	0.7606	0.0788
					Sense of Belonging	0.2394	0.0305
		Emotional Experience	0.3426	0.0825	Sense of Accomplishment	0.2329	0.0193
					Interest	0.7671	0.0633
		Emotional Regulation	0.1295	0.0312	Cognitive Reappraisal	0.2125	0.0067
					Emotional Transfer	0.7875	0.0246

5.1.2 To Identify Blended Learning Engagement Evaluation System for University in China. A model for assessing evaluation indicators was developed by inviting 100 experienced teachers from five universities in Sichuan Province, China to conduct a secondary assessment. These educators specialize in blended teaching and were able to impartially define the parameters for each indicator. Ultimately, the resulting model provides an effective framework for evaluating participation in blended learning at universities. blended learning has been proven to be an effective approach in education and has revolutionized the way learners take charge of their own learning. By embracing blended learning, learners can cultivate self-motivation, develop critical thinking skills, and become active participants in their own educational journey. As a result, they become more engaged and invested in their learning process, leading to better retention of knowledge and improved academic performance.

Table 5.2 Blended Learning Evaluation System for University in China

	First-level Indicators	**Second Level Indicators**	**Third Level Indicators**
Blended Learning Engagement	Behavioral Engagement (0.5680)	Participate (0.0787)	Number of Online Platform Logins(0.0308) Online Platform Task Completion(0.0231) Frequency of Answering Questions In Class(0.0154) Classroom Attendance(0.0097)
		Focus(0.1949)	The Amount of Video Played Per Unit time(0.0264)Amount of Classroom Tasks Completed(0.0976) Classroom Performance(0.0710)
		Interaction (0.0838)	Discussion Popularity On Online Platforms(0.0391) Peer Reviews and Feedback(0.0263) Teacher-Student Interaction(0.0185)
		Persistence (0.0684)	Overcome Difficulties(0.0115) Online Task Persistence(0.0363) Maintaining a High Level of Engagement In The Classroom(0.0208)

Table 5.2 Blended Learning Evaluation System for University in China (Cont.)

	First-level Indicators	**Second Level Indicators**	**Third Level Indicators**
		Self-monitoring (0.1422)	Clarify Goals and Requirements(0.0389) Self-evaluation and reflection(0.0215) Learning Environment Adjustment(0.0819)
	Cognitive Engagement (0.1914)	Depth of thinking (0.0626)	Logic and Critical Thinking(0.0211) Creative Thinking and Problem Solving(0.0302) Interdisciplinary Thinking and Associations(0.0114)
		Learning Strategies (0.1288)	Summarization and Induction Ability(0.0663) Self-test and Rhetorical Questions(0.0626)
	Emotional Engagement (0.2407)	Self-Worth (0.1270)	Identity(0.0788) Sense of Belonging(0.0305)
		Emotional Experience (0.0825)	Sense of Accomplishment(0.0193) Interest(0.0633)
		Emotional Regulation (0.0312)	Cognitive Reappraisal(0.0067) Emotional Transfer(0.0246)

5.2 Discussion

The model displays a total of 3 main indicators, 10 additional indicators, and 27 tertiary indicators. Among the primary indicators, the assessment criteria for behavioural engagement outnumber those for emotional engagement and cognitive engagement. This discrepancy can be primarily attributed to several factors: (1) Observable Nature: Behavioural participation measures are generally more easily observable and quantifiable. Student behaviours such as online platform involvement, task completion, and classroom attendance can be measured through recording and statistical data collection methods-this makes it simpler to incorporate these indicators into the evaluation system (Liang et al., 2018), (2) Direct Correlation: Behavioural engagement directly mirrors students' tangible actions and level of involvement in the learning process. These behaviours often have a close connection to students' learning outcomes and experiences; therefore, they receive greater attention and weighting within the evaluation system (Manz et al., 2013), (3) Influence Factors: Emotional engagement and cognitive engagement are frequently affected by more intricate factors like individual emotional states and cognitive abilities—which are relatively challenging to quantify accurately without introducing subjectivity or inaccuracy; hence reducing their corresponding indicator numbers in the evaluation system (Evans & Zhu, 2023), (4) Importance & Priority: In certain scenarios involving practical course content application coupled with teamwork dynamics–behavioral commitment significantly impacts learning quality & effectiveness thus making it more pivotal than others (Gong, 2020). It's important that while there may be an abundance of behavioral related cues- we must not overlook how critical emotional investment is just as well as psychological tactics used during academic sessions lies too. In order to ensure effective assessment on student activity -evaluative systems shall take into account all three dimensions equally efficient way. Based on the assigned weights, it is evident that "Behavioral Engagement" holds a weight of 0.568 among the secondary indicators. This dimension bears the greatest weight, signifying its essential role in the overall assessment. From this, we can infer that assessors regard behavioral engagement as paramount in influencing learning engagement and outcomes within blended learning settings.The allocation of higher weights signifies a substantial contribution to the comprehensive evaluation, while lower weights denote a comparatively minor influence on the overall assessment. This distribution of weights mirrors evaluators' comprehension and prioritization of various engagement dimensions concerning learning engagement and outcomes.

When evaluating Behavioral Engagement, the "Participate" indicator examines students' active involvement in blended learning activities. It includes behaviors such as the frequency of online platform logins, completion status of tasks, participation in class discussions by responding to questions, and physical classroom attendance. These measures provide a more comprehensive understanding of students' levels of engagement. The "Number of Online Platform Logins" refers to how often students access the online learning platform, with frequent logins suggesting active participation in online learning activities. "Online Platform Task Completion" indicates students' progress in completing course tasks on the online platform and reflects their active engagement and time investment in these tasks. "Frequency of Answering Questions in Class" assesses how regularly students actively participate in class discussions by answering questions, demonstrating their level of involvement during the learning process. Lastly, “Classroom Attendance" denotes students’ presence at physical classroom sessions as an indication of their level 9fparticipationin face-to-face teaching. These indicators are selected as evaluation criteria for learning engagement because they directly measure students' behavioral involvement in the learning process, which is a crucial manifestation of students' learning motivation, initiative, and effectiveness. The "Focus" indicator is used to assess students' concentration levels in the blended learning environment. It comprises three tertiary indicators: (1) "The Amount of Video Played Per Unit Time" measures the duration students spend watching videos online, typically quantified in minutes per unit of time. Longer viewing times may indicate higher levels of focus on video content. (2) "Amount of Classroom Tasks Completed" indicates the number of classroom tasks completed by students, with more completed tasks potentially indicating a higher level of engagement with course content (3) Classroom Performance" assesses students' performance in physical classroom settings, including participation in discussions, asking questions, and answering questions. Positive classroom performance may reflect students' engagement with teaching activities.

These criteria have been selected as assessment measures for student engagement because they directly evaluate students' active participation in the learning process, a key display of their motivation, initiative, and effectiveness. The "Focus" measure is utilized to gauge students' level of concentration in the blended learning environment. It consists of three sub-measures:(1)Time Spent Watching Videos quantifies the duration that students dedicate to watching online videos, often measured as minutes per time unit. Longer viewing durations may indicate a higher focus on video content, (2) "Completion of Classroom Tasks" indicates the number of tasks completed by students, with more completed tasks potentially signaling greater engagement with course material, (3) "Classroom Performance" evaluates students’ performance in physical classroom settings such as participation in discussions, asking and answering questions. Positive classroom performance may reflect students' involvement in teaching activities. “The "Interaction" metric focuses on assessing students' engagement in blended learning through three key measures: (1)"Popularity of Online Discussions" evaluates the extent of student participation and the level of attention their contributions receive from peers. A high popularity may indicate active interaction within the learning community. (2) "Peer Reviews and Feedback" assesses both the quantity and quality of peer reviews, emphasizing collaborative learning and support amongst students for improved academic involvement. (3) "Teacher-Student Interaction" gauges the frequency and quality of interactions between teachers and students to facilitate better understanding, leading to enhanced comprehension and effectiveness in learning outcomes. The indicator of "Persistence" evaluates the students' capability to continue learning and handle challenges in the blended learning environment. This includes three secondary indicators: (1) "Overcoming Challenges" assesses if students have the ability to tackle difficulties encountered during their academic journey, such as solving problems and overcoming obstacles. (2) The "Online Task Persistence" measures the student's capacity to persist in completing tasks on online platforms which requires self-discipline and patience, crucial for success in blended learning.(3) The assessment of "Maintaining a High Level of Engagement in The Classroom" focuses on evaluating whether students can sustain high levels of participation and attention in physical classroom settings leading to enhanced effectiveness in learning. Similarly, the indicator for "Self-monitoring," evaluates a student's abilities within this context through these tertiary indicators: “Clarifying Goals & Requirements"- Assesses whether students are able to define clear goals & requirements aiding them directionally pursue their studies. "Self-evaluation Reflective Abilities "- Evaluates how well they can self-assess, reflect upon performances making improvements enhancing overall learning effectiveness, (3) Learning Environment Adjustment-It examines adjustment capabilities concerning suitable places/times/resource management based on individualized needs. When evaluating cognitive engagement in a blended learning environment, the "Depth of thinking" is utilized to gauge students' analytical abilities. It consists of three key indicators with varying weights. (1) "Logic and Critical Thinking" assesses students' capacity to apply logic and critical thinking when analysing problems, evaluating information, and making decisions, (2) "Creative Thinking and Problem Solving" evaluates students' ability to develop innovative ideas, propose new perspectives, and solve problems creatively, and (3) "Interdisciplinary Thinking and Associations" examines if students can make connections across different fields for interdisciplinary problem-solving. The secondary indicator "Learning Strategies" is used to evaluate how students utilize learning methods in the blended learning environment through two tertiary indicators: 1."Summarization and Induction Ability", which measures whether they can summarize complex information effectively, (2)"Self-test and Rhetorical Questions", which evaluates their use of self-testing techniques for memory consolidation.

Collectively, these indicators comprehensively assess student engagement by considering critical thinking skills, creative problem-solving abilities, interdisciplinary connections as well as effective learning strategies within the context of blended learning environments. When looking at emotional involvement indicators, the assessment of students' perceptions of their own worth and their emotional commitment to self-esteem and confidence is captured in the "Self-Worth" category. This includes two main components: (1) "Identity" pertains to how much students invest emotionally in their sense of self-identity and value, which can impact their enthusiasm and confidence in learning, and (2) "Sense of Belonging" measures the extent to which students feel connected, integrated, and accepted within the school or learning community, reflecting their emotional attachment and sense of belonging. Under secondary indicators, "Emotional Experience" evaluates students' responses in a blended learning environment using these two components: (1) "Sense of Accomplishment," capturing emotions after completing tasks or achieving academic goals, (2) The measurement for student interest reflects its significance on motivation; it determines investment levels towards topics or tasks that align with personal interests.

Within this framework are also assessments related to Emotional Regulation abilities including cognitive reappraisal techniques such as managing responses through thinking strategies as well as transferring emotions from one context to another for maintaining balance. Together these aspects offer valuable insights into aspects like student engagement, perception about oneself, feelings associated with experiences encountered throughout studies alongside fostering skills required for emotion regulation essential within a mixed mode educational system experience**.**

The aim of this study is to conduct a comprehensive analysis of student involvement and qualities in blended learning at universities and establish a corresponding assessment index system, which will be validated using statistical methods. Developing this evaluation index system is crucial for gaining a deeper understanding of the level of students' engagement in blended learning environments. It can provide educators and policymakers with scientifically effective assessment tools to enhance learning environments and teaching methods, thereby fostering students' learning and development. To begin with, the research team formulated an assessment framework for student engagement in blended learning based on three dimensions: "behavior," "cognition," and "emotion." This multidimensional framework was derived from literature analysis and relevant theories in blended learning while considering various aspects of student engagement. This theoretical framework served as a strong basis for establishing subsequent evaluation indicators, thus improving the accuracy and comprehensiveness of the assessment system. The study utilized the Delphi method for semi-structured expert interviews to integrate interdisciplinary expert opinions. This approach not only enhanced objectivity but also fully leveraged experts' experience from different fields, resulting in more comprehensive evaluation indicators. Moreover, The indicators were further improved, and surveys were created for both students and teachers. Additionally, a scale to measure student engagement was developed. Gathering data from various stakeholders allowed for a comprehensive comprehension of student engagement. Statistical software like SPSS was employed to analyze the data and assess the functionality and applicability of the assessment index system.

Lastly, The Analytic Hierarchy Process was utilized to create pairwise comparison matrices, followed by data normalization and consistency testing to calculate the weights of each indicator level. This approach guaranteed that the significance of each indicator in the evaluation system was accurately measured and verified, thereby bolstering the credibility and dependability of the evaluation findings. The advantages of this evaluation system are as follows:(1) Comprehensive assessment of student engagement: It covers multiple aspects of student engagement, including behaviours, cognition, emotions, and self-regulation. This enables schools or educational institutions to have a more comprehensive understanding of students' performance and level of involvement in blended learning environments, and (2) Multilevel assessment: It adopts a multilevel structure with primary, secondary, and tertiary indicators, making the evaluation more refined. This allows schools to weight different levels of indicators according to specific needs and importance, better meeting their evaluation and improvement goals, (3) Inclusion of emotional and social factors: In addition to academic performance, it also focuses on students' emotional and social aspects, such as emotional engagement, emotional experiences, self-regulation, and sense of belonging. This helps understand students' sense of well-being and overall learning experience, (4) Promotion of personalized support: By assessing different levels of indicators, schools can better identify students' strengths and needs, providing more personalized support and guidance, (5) Continuous improvement of educational strategies: By monitoring trends in different indicators, schools can identify problem areas and take measures to improve students' academic and emotional engagement, (6) Increased student engagement: By gaining a deeper understanding of students' engagement at different levels, schools can take measures to enhance students' academic motivation and level of involvement, thereby improving their learning outcomes.

In summary, the strength of this indicator system lies in its provision of a multidimensional approach to assess students' academic and emotional engagement. This aids schools in gaining a deeper understanding of students' needs and performance, enabling them to enhance educational strategies and offer better support. It contributes to fostering academic success and overall well-being among students.On the other hand, this assessment indicator system also boasts features such as comprehensive evaluation, multilevel assessment, coverage of emotional and social factors, promotion of personalized support, continuous improvement of educational strategies, and increased student engagement. In comparison to other indicator systems, it possesses unique advantages. It allows institutions to comprehensively gauge students' performance in a blended learning environment, provide more tailored support, and continuously refine educational strategies to boost student motivation and academic achievement.This assessment indicator system is not only a scientific tool for educational evaluation but also a basis for informed decision-making in education. It facilitates the ongoing development and enhancement of higher education blended learning. Therefore, the results of this research hold significant implications for advancing the field of education.In conclusion, the strength of this indicator system lies in its multidimensional approach to assessing students' academic and emotional engagement, which aids schools in better understanding student needs and performance, thus improving educational strategies and support. This contributes to promoting .students' academic success and overall well-being

5.3Limitations

Based on engagement learning theory, student participation theory and other related theories related to online learning engagement, the theoretical framework was determined and an evaluation index system for college students’ online learning engagement was constructed. Application research was carried out and certain theoretical and practical research was achieved. Results. However, when studying the investment evaluation system of hybrid schools in colleges and universities, some of the limitations you summarized are as follows:(1) The sample is too small : The sample used in the study only includes experts from different universities but does not cover the comprehensive situation of hybrid schools in China's universities. These experts may only represent the views and recommendations of schools of a specific type or region, and fail to cover other potential factors and diversity, which may limit the generalizability and general applicability of the research conclusions. Failure to include a broadly representative sample may result in conclusions that cannot be broadly generalized to tertiary hybrid schools across the country. (2) Data collection: The data sources used in the research include questionnaires, interviews, observations, etc. These data may be affected by factors such as the subjective wishes, recall bias, or self-statement of the respondents. Respondents may be biased or not completely objective when answering questions, causing problems with the objectivity and accuracy of the data. This data bias may affect the authenticity and credibility of the research results, thereby affecting the accuracy and reliability of the conclusions. (3) Time constraints: There may be time constraints during the research process, which prevents full and in-depth research and analysis of all factors that may affect the investment in hybrid schools in colleges and universities. Due to limited time, some important factors may not be fully investigated and examined, thus affecting the completeness and comprehensiveness of the research results, and (4) External factors: Investment in hybrid schools in colleges and universities is affected by many external factors, such as policy changes, economic environment, etc. However, these external factors are often beyond the control of the researcher and may be difficult to predict and control. These unconsidered external factors may have certain interference and influence on the research results, limiting the reliability and stability of the conclusions to a certain extent.

5.4 Contributions

This study addresses the existing gap by introducing a comprehensive evaluation system for blended learning engagement. The assessment system not only identifies students' engagement in blended teaching but also utilizes various indicators to offer a detailed overview of their participation in blended learning. For educators and educational policymakers, the evaluation model serves as a tool to focus on nurturing and enhancing students' learning engagement, ultimately leading to improved academic performance, and expanded knowledge. Firstly, through an in-depth analysis of students' learning engagement and characteristics in blended learning environments, this research presents an effective approach to fill the void in the evaluation system for blended learning. The establishment of this assessment system not only enables educational institutions to gain a comprehensive understanding of students' learning behaviours and participation levels but also provides valuable insights for instructional improvements. Secondly, the establishment of the evaluation model provides schools and educational management departments with a scientific assessment tool, aiding them in better formulation of teaching strategies and educational policies. By gaining insights into students' learning engagement in blended learning, educators can adjust their teaching methods based on evaluation results, thereby enhancing students' learning outcomes.

Lastly, the development of this evaluation system holds significant implications for students' learning and growth. By focusing on and enhancing students' learning engagement, educational institutions can foster students' autonomy and teamwork skills, facilitating their overall development and better preparation for future societal demands. Therefore, the establishment of the evaluation model is of paramount importance for students' personal and professional development.

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https://doi.org/10.1016/0361-476x(86)90027-5

AppendixA.

List of Experts

The experts were:

1.Professor Shen Minghong, Ph.D. Chief expert of the College of Education and Psychology, Ph.D. in Developmental and Educational Psychology from Capital Normal University.

2.Professor He Jibo, Ph.D. in Psychology from the Illinois Institute of Technology.

3.Associate Professor Chen Tong, Ph.D. in Developmental and Educational Psychology from Southwest University.

4.Associate Professor Deng Liqun, Ph.D. Department Chair of Education at Southwest University.

5.Associate Professor Zhang Yi, Ph.D. in Developmental and Educational Psychology from Sichuan Normal University.

6.Professor Sun Lan, Ph.D. in Education from Southwest University.

7.Associate Professor Zhuo Jin, Ph.D. in Education from Capital Normal University.

8.Associate Professor Li Bo, Ph.D. in Education from Sichuan Normal University.

9.Professor Huang Jie, Ph.D. in Philosophy of Education from Southwest University.

10.Professor Chen Zhuo, Ph.D. in Education from Clemson University.

11.Associate Professor Peng Mingfang, Ph.D. in School Education from Southwest University.

12.Professor Liao Guoqiang, Ph.D. in Education from Southwest University.

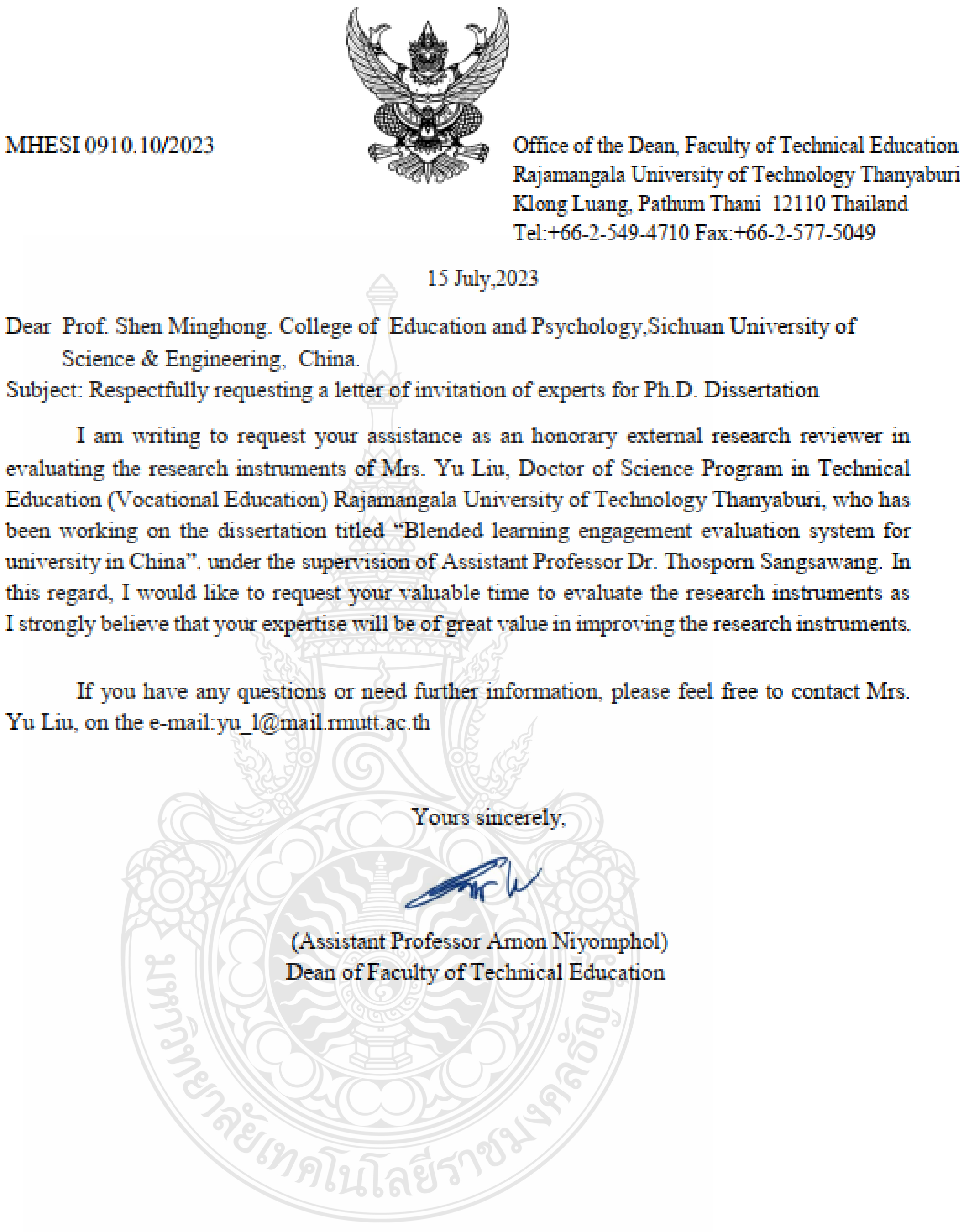
13.Associate Professor Tang Yuan, Ph.D. in Educational Economics and Management from China West Normal University.

14.Associate Professor Chen Chao, Ph.D. in Ideological and Political Education from Peking University.

15.Professor Fan Guangjie, Ph.D. in Ideological and Political Education from Southwest Jiaotong University.

16.Professor Fan Zhixuan, Ph.D. in Ideological and Political Education from Fudan University.

17.Associate Professor Zhao Xue, Ph.D. in Developmental and Educational Psychology from Southwest University.



MHESI 0910.10/2023

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15 July,2023

Dear Prof. Shen Minghong. College of Education and Psychology,Sichuan University of
Science & Engineering, China.

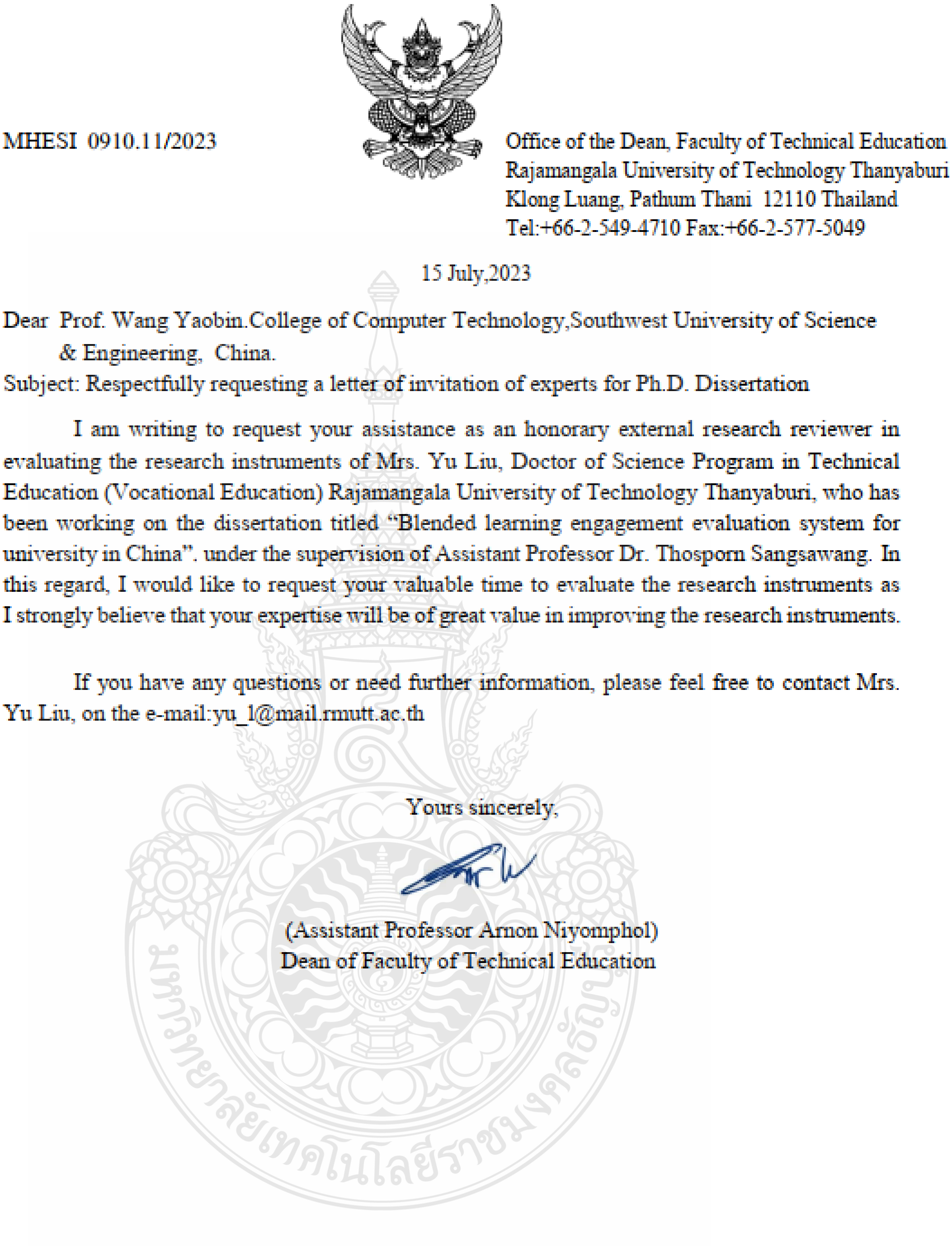
Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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 Mrs. Yu Liu, on the e-mail:yu_l@mail.rmutt.ac.th

Yours sincerely,

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



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15 July,2023

Dear Prof. Wang Yaobin.College of Computer Technology,Southwest University of Science & Engineering, China.

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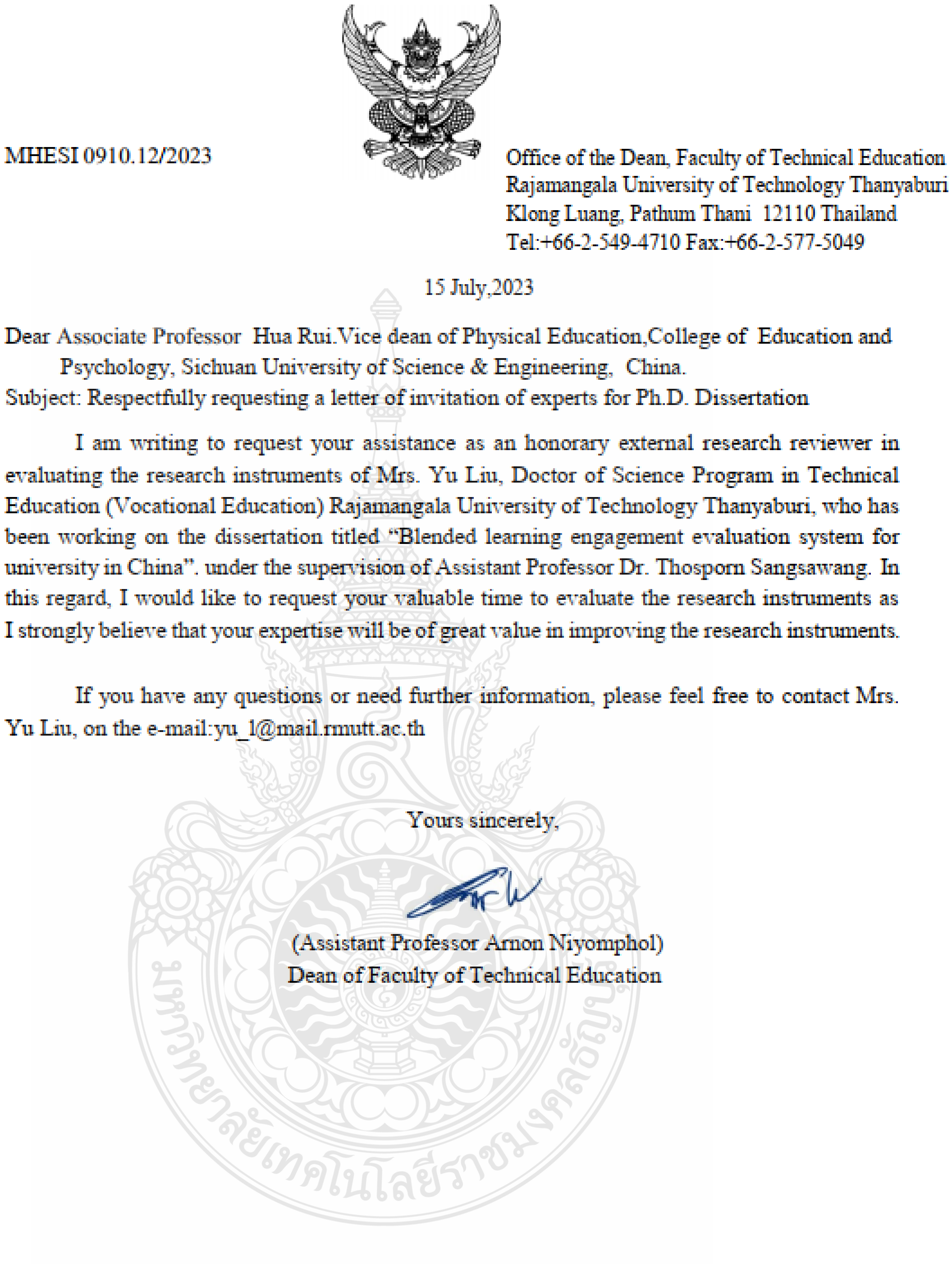
If you have any questions or need further information, please feel free to contact Mrs. Yu Liu, on the e-mail:yu_l@mail.rmutt.ac.th

Yours sincerely,

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



MHESI 0910.12/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

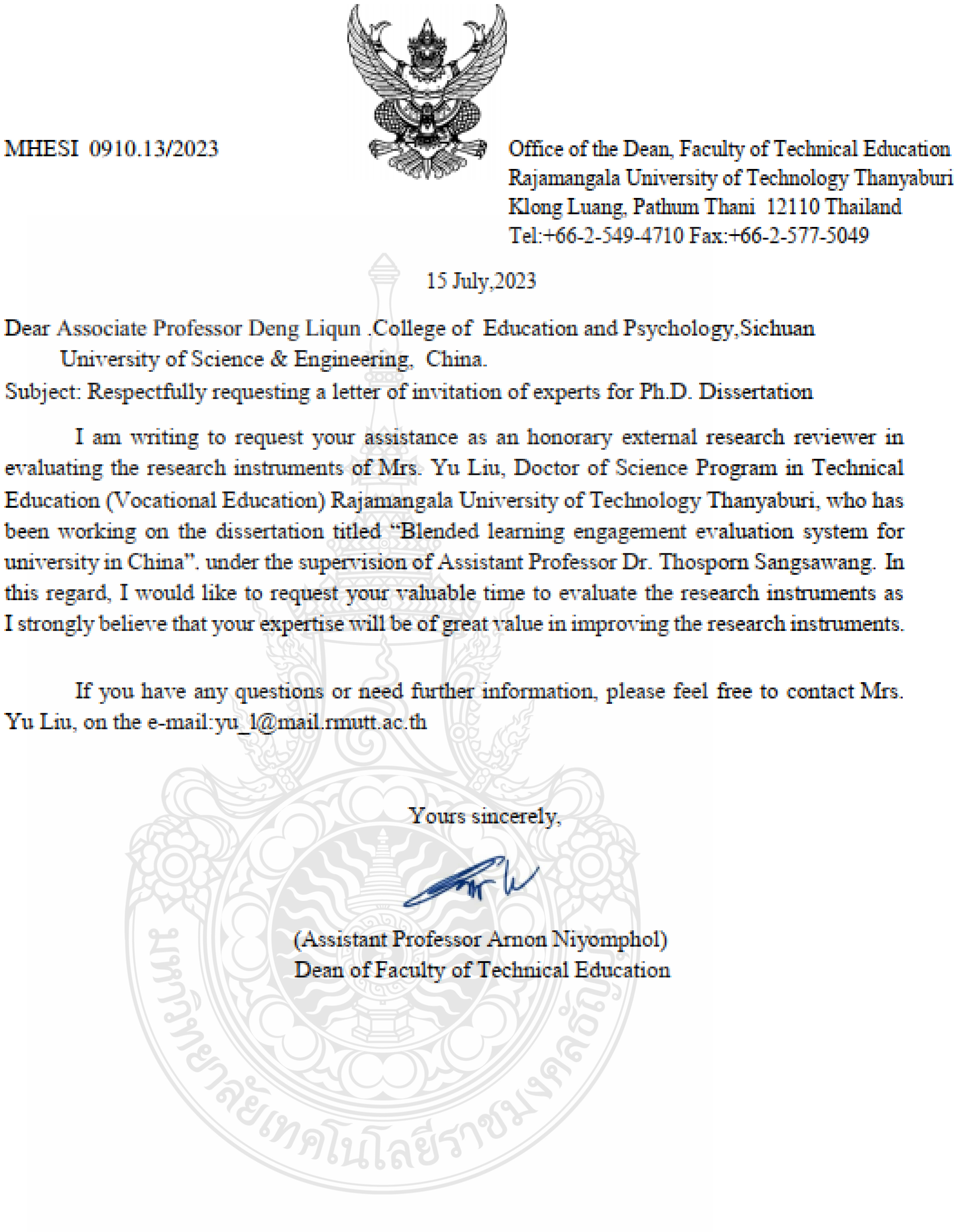
Dear Associate Professor Hua Rui.Vice dean of Physical Education,College of Education and
Psychology, Sichuan University of Science & Engineering, China.
Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

I am writing to request your assistance as an honorary external research reviewer in evaluating the research instruments of Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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 Mrs. Yu Liu, on the e-mail:yu_l@mail.rmutt.ac.th

Yours sincerely,

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



MHESI 0910.13/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Deng Liqun .College of Education and Psychology,Sichuan
University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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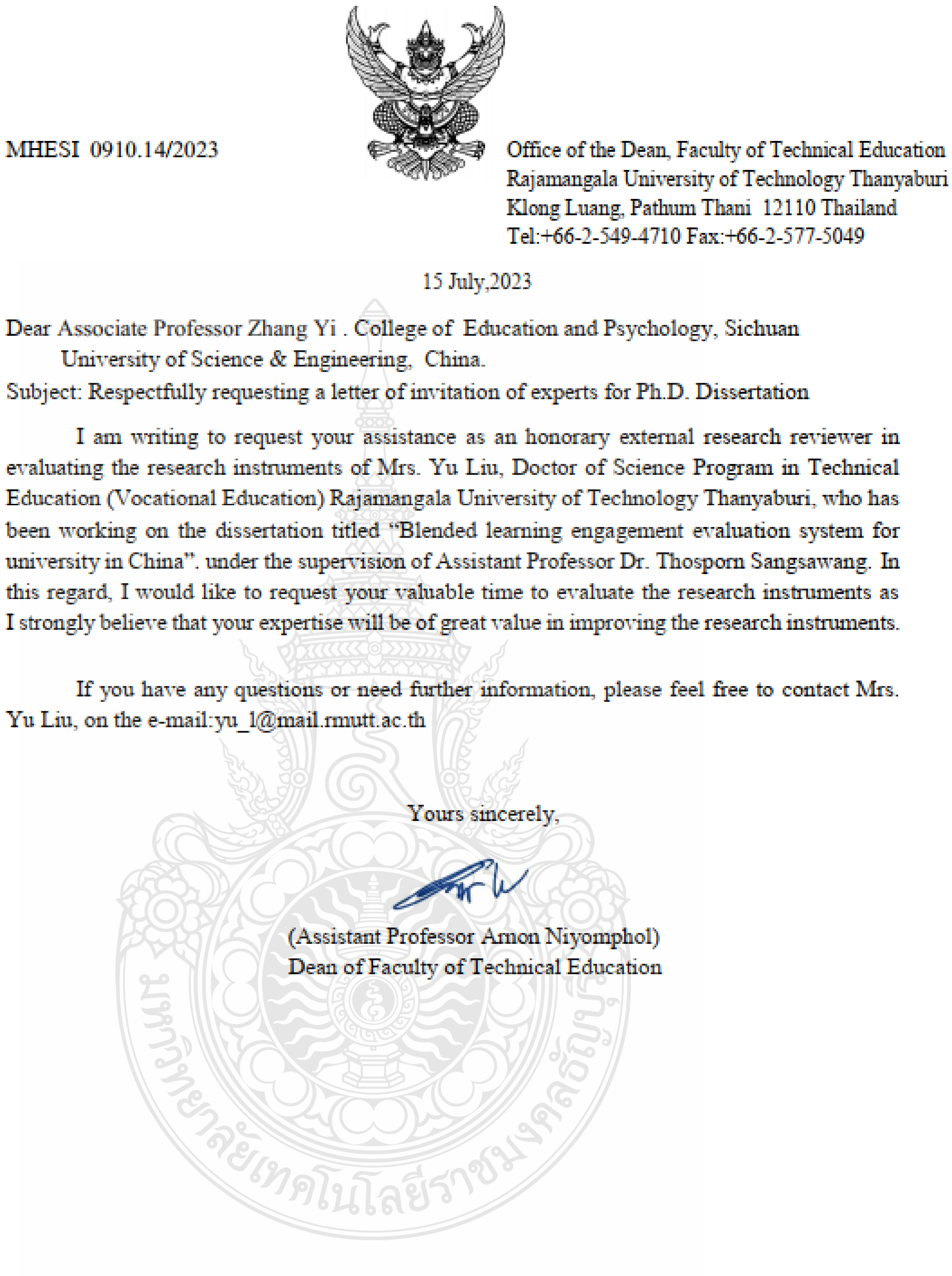
Dean of Faculty of Technical Education



MHESI 0910.14/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Zhang Yi . College of Education and Psychology, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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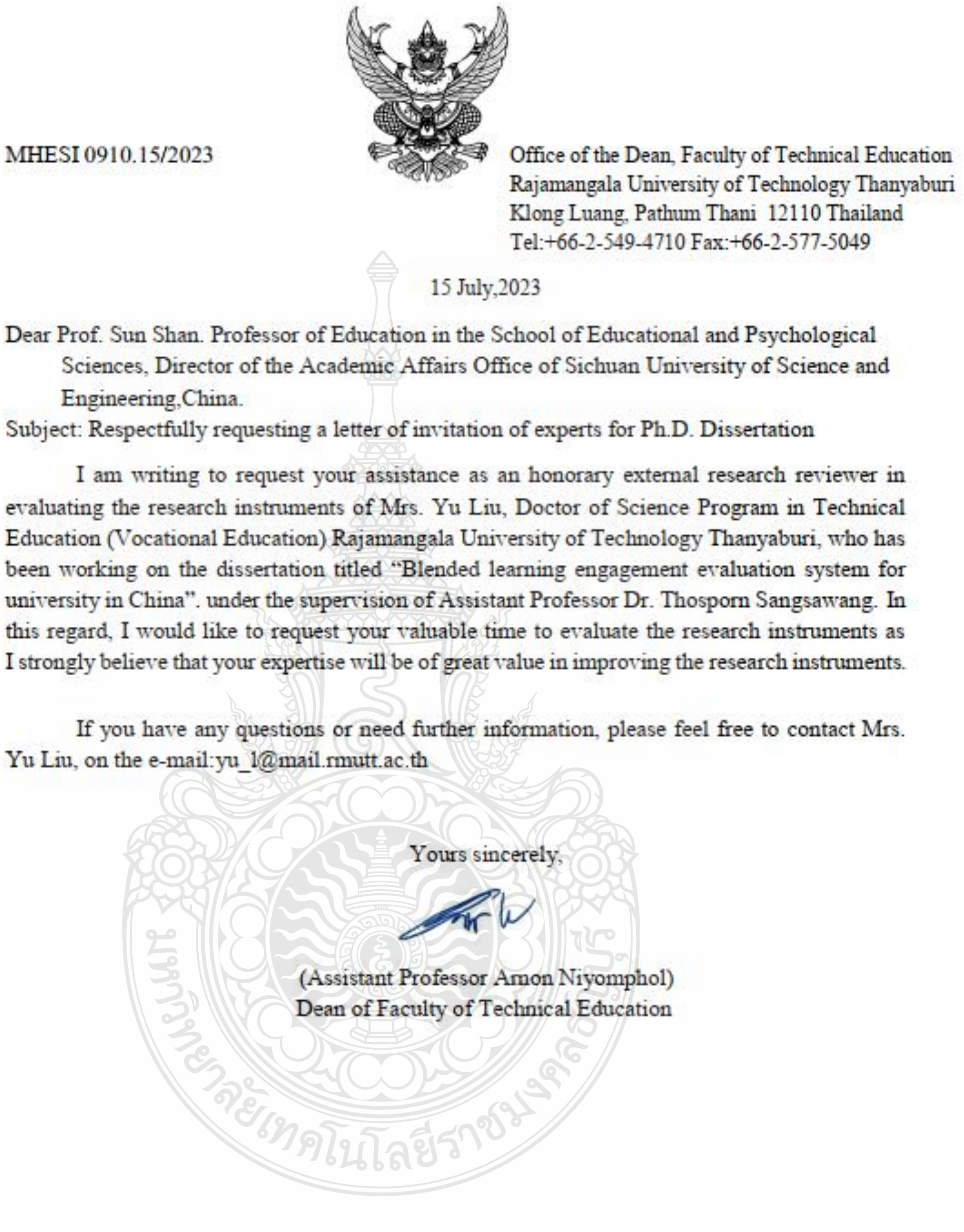

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Prof. Sun Shan. Professor of Education in the School of Educational and Psychological Sciences, Director of the Academic Affairs Office of Sichuan University of Science and Engineering,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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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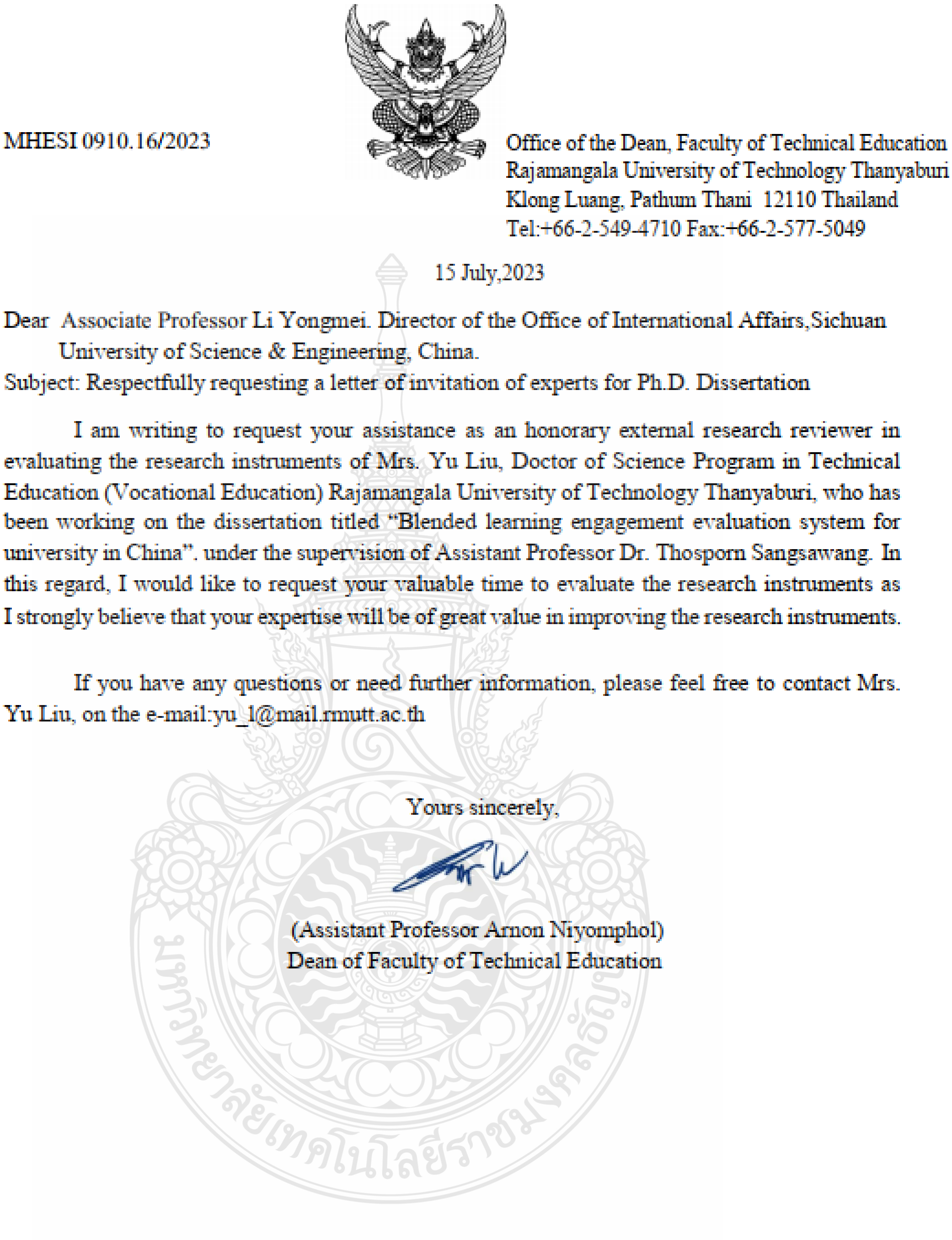

MHESI 0910.16/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Li Yongmei. Director of the Office of International Affairs,Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled “Blended learning engagement evaluation system for university in China”. under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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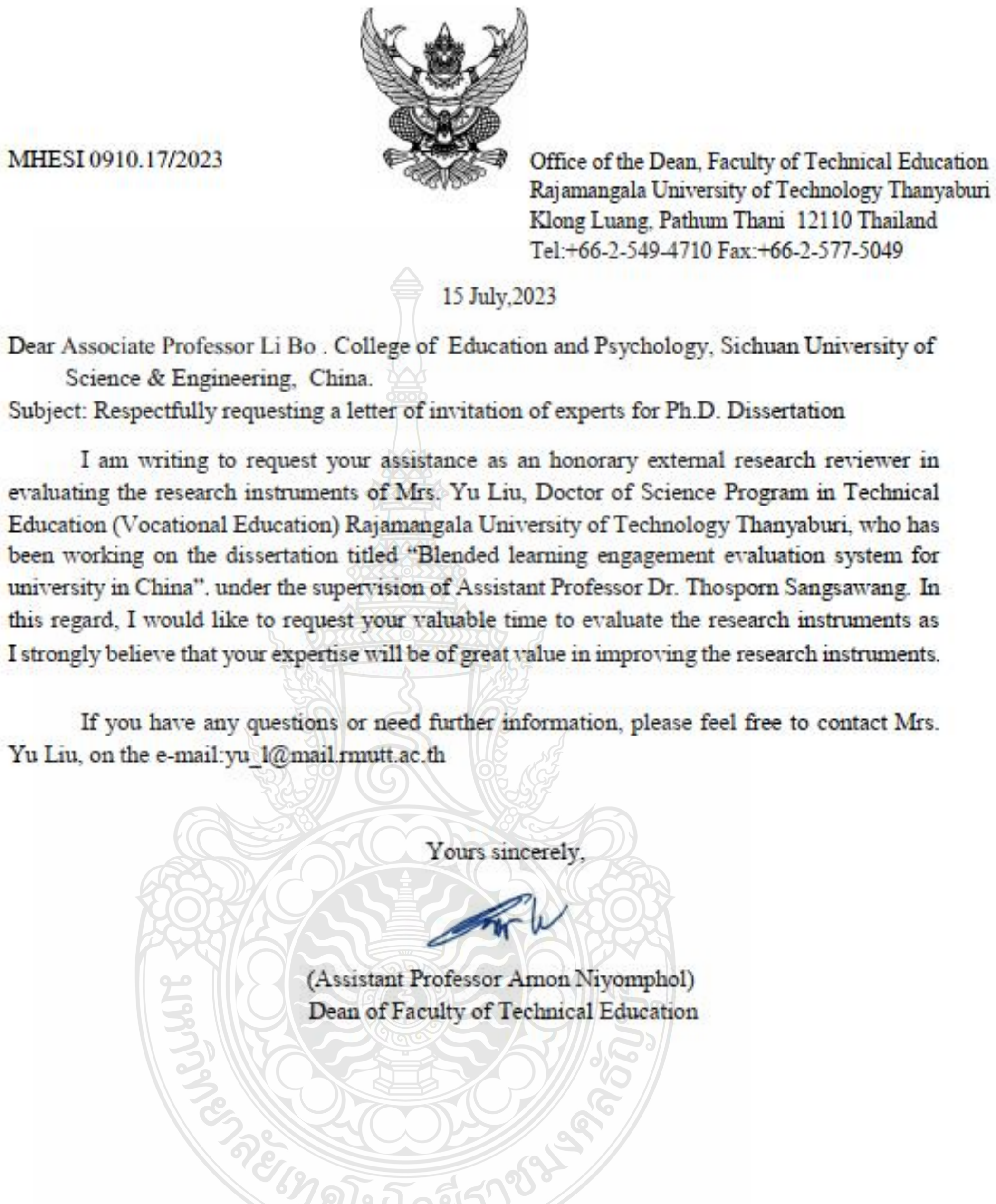

MHESI 0910.17/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Li Bo . College of Education and Psychology, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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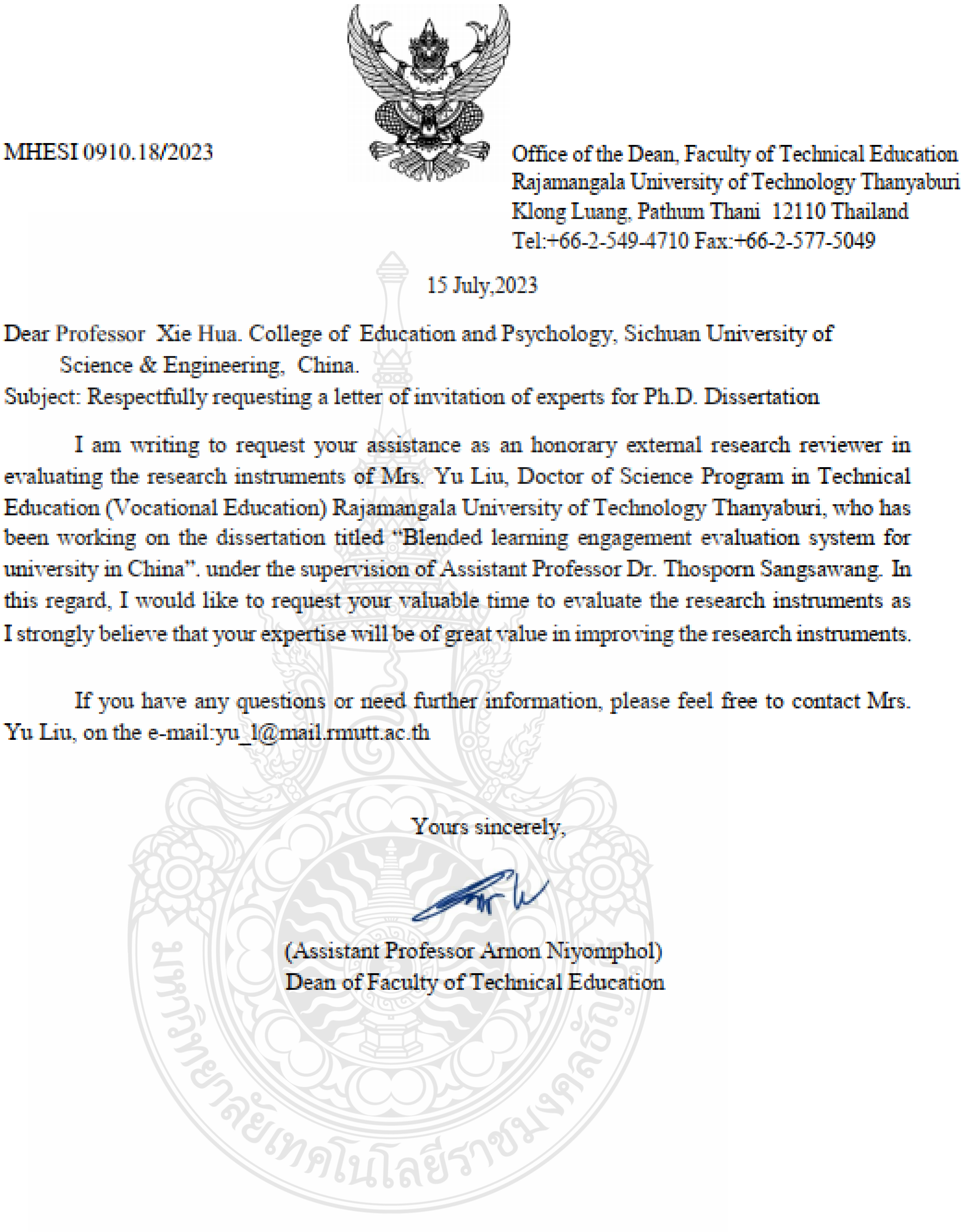
Dean of Faculty of Technical Education



MHESI 0910.18/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Professor Xie Hua. College of Education and Psychology, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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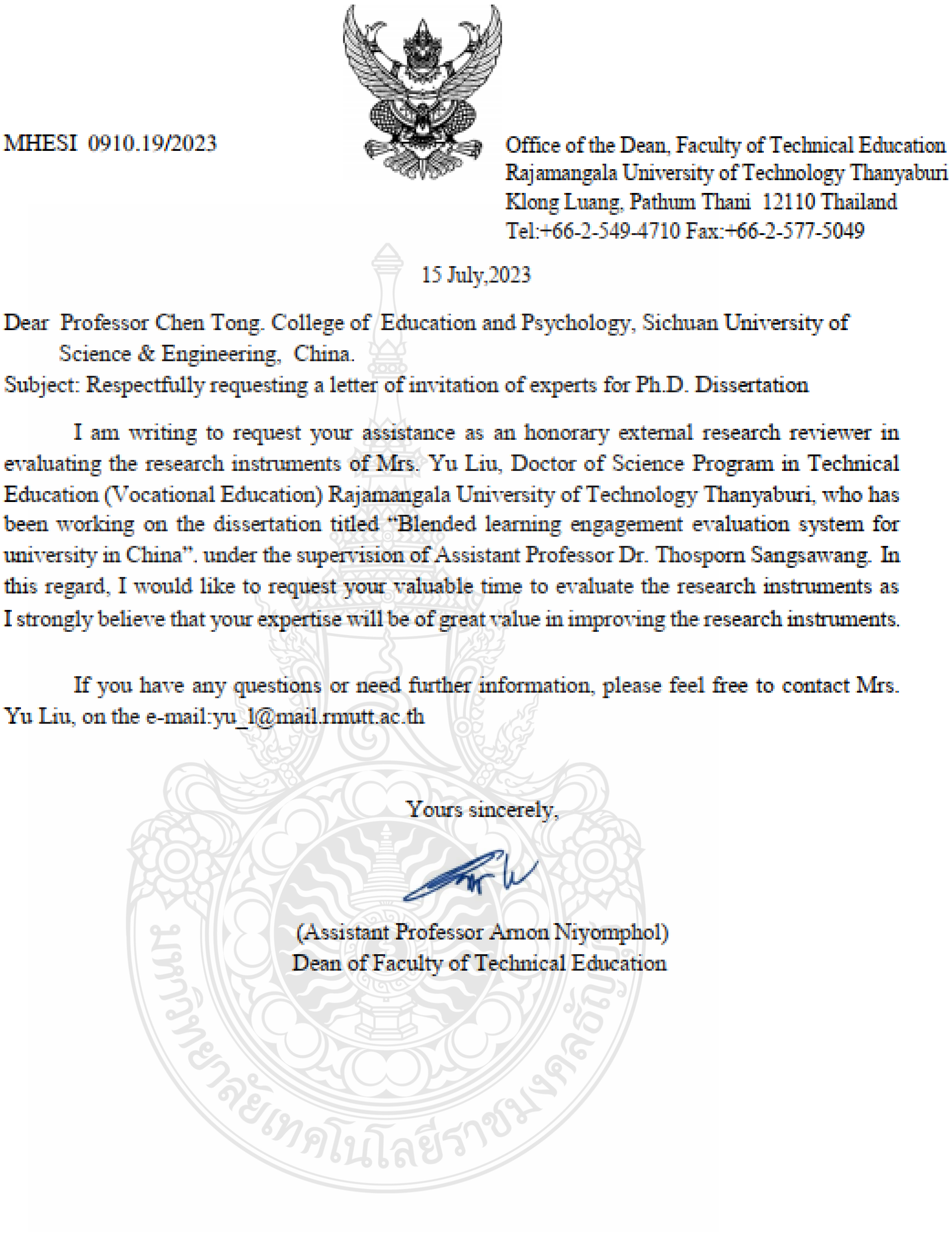

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Professor Chen Tong. College of Education and Psychology, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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 Mrs. Yu Liu, on the e-mail:yu_l@mail.rmutt.ac.th

Yours sincerely,

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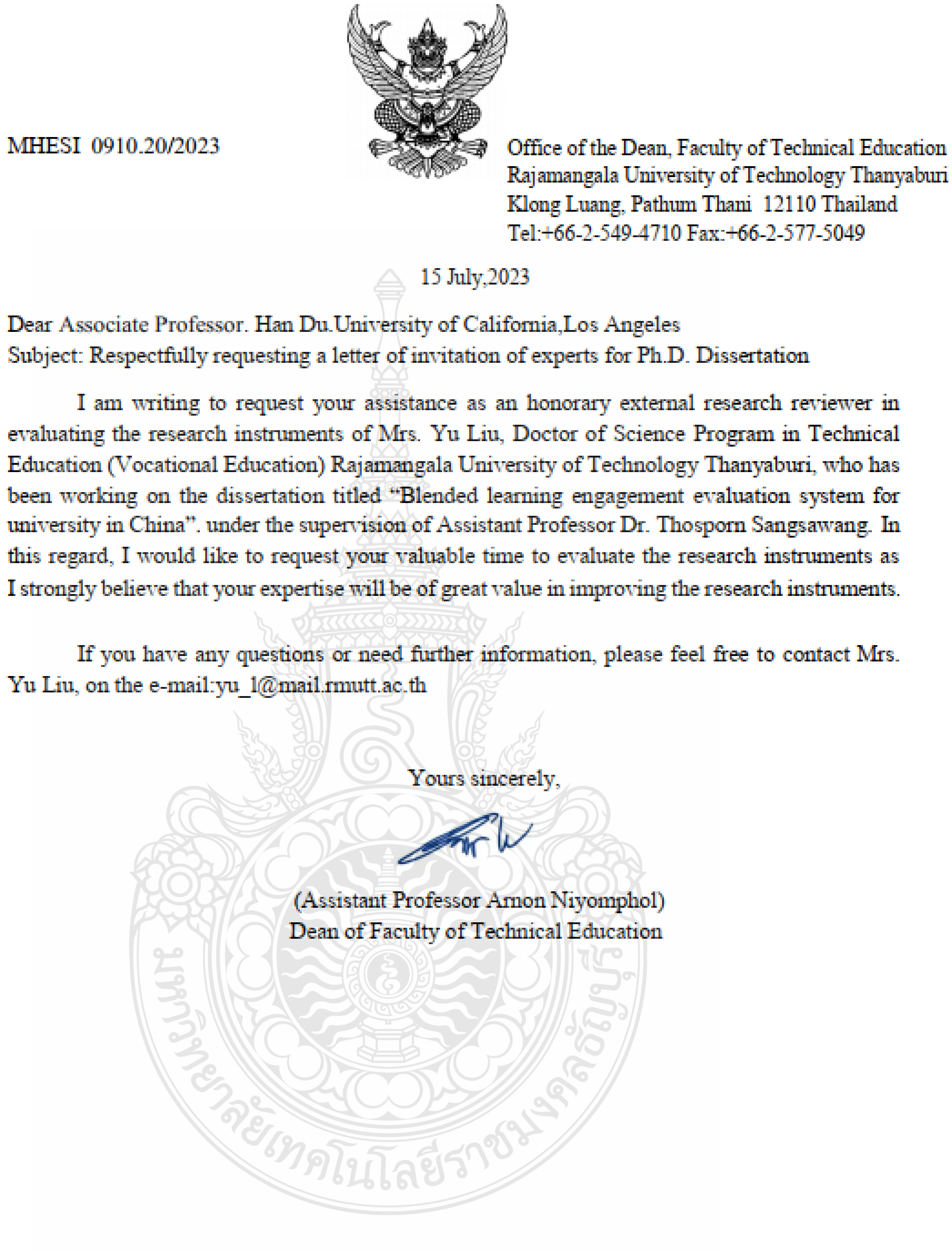
Dean of Faculty of Technical Education



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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor. Han Du.University of California,Los Angeles
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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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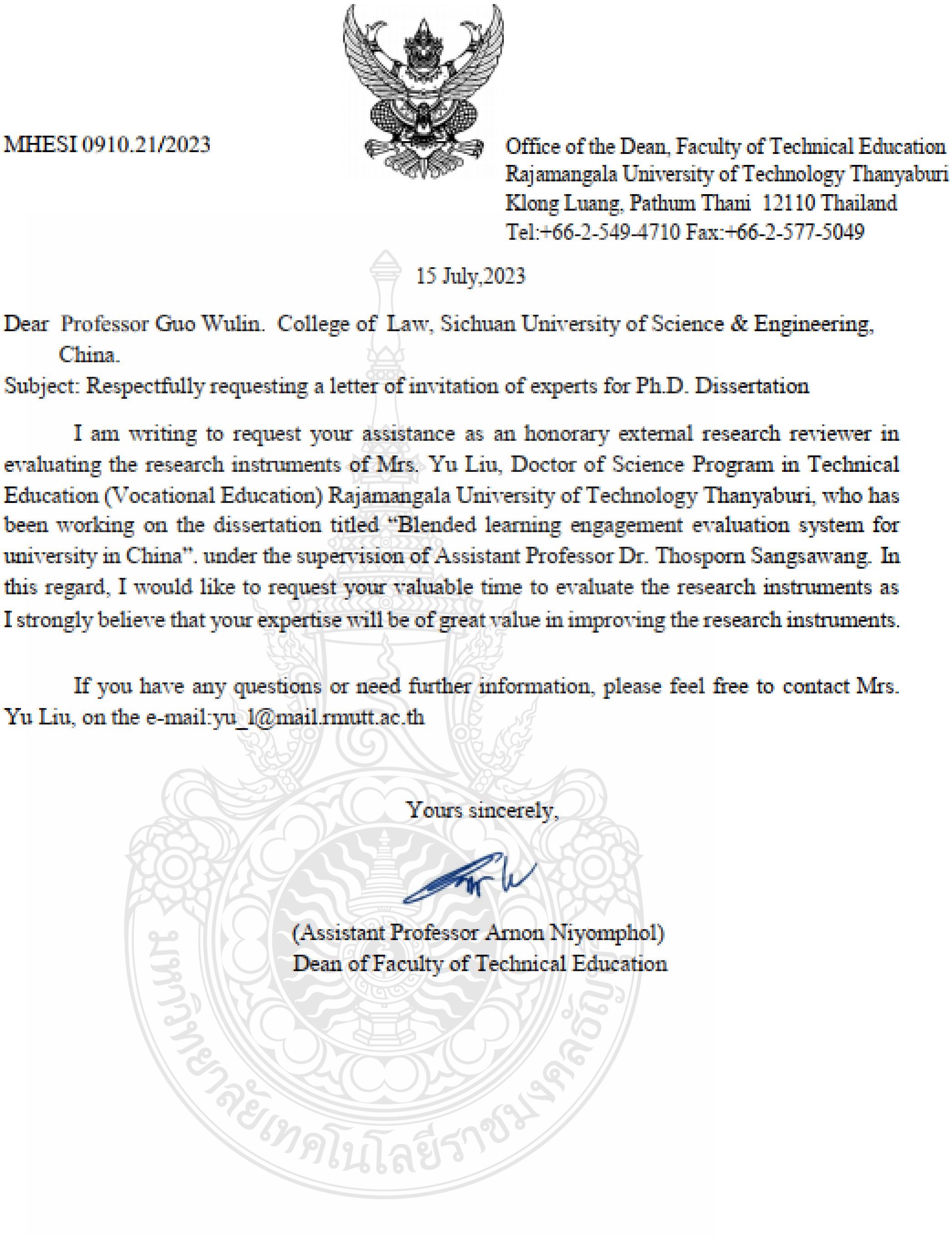
Dean of Faculty of Technical Education



MHESI 0910.21/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Professor Guo Wulin. College of Law, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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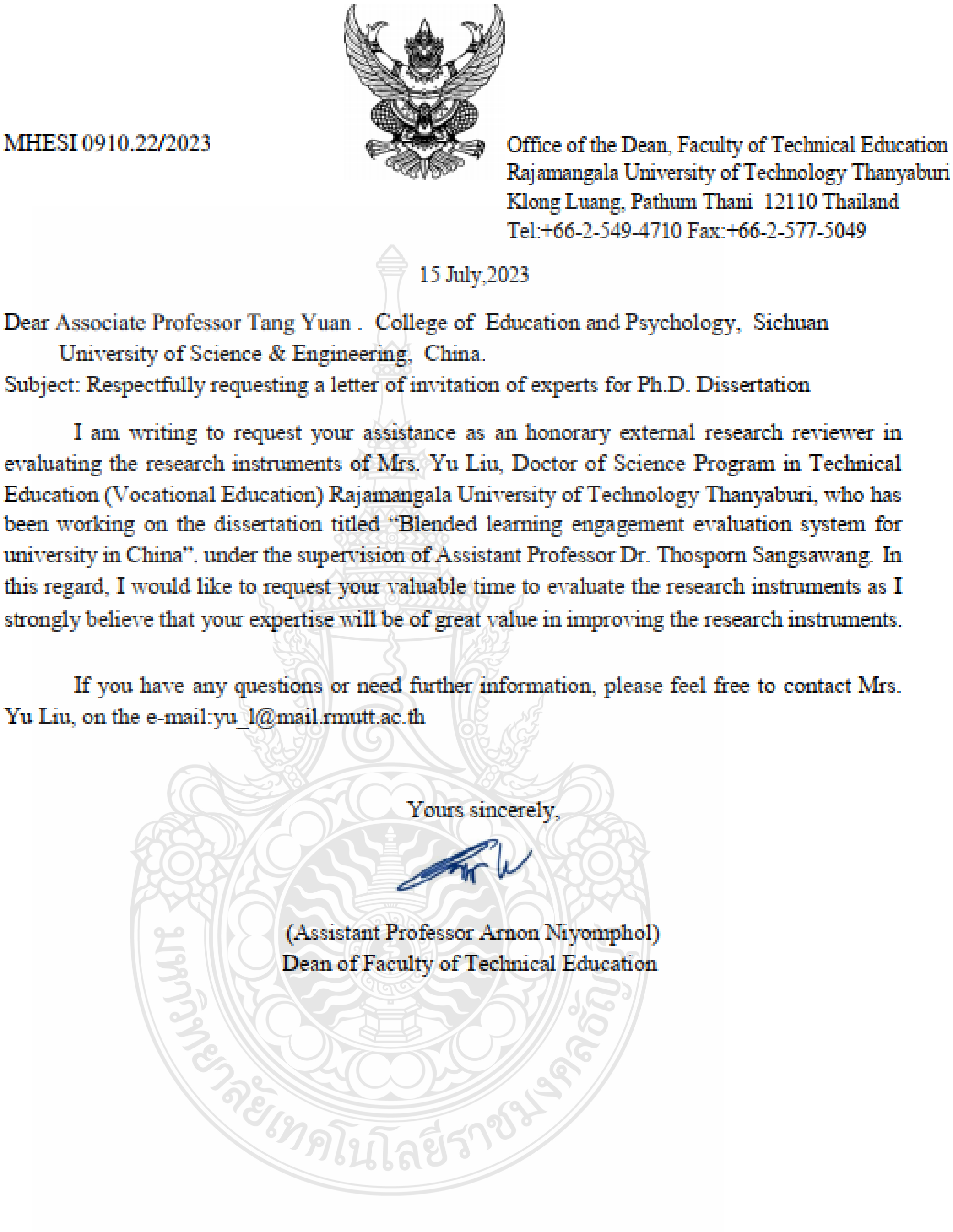
Yours sincerely,

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



MHESI 0910.22/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Tang Yuan . College of Education and Psychology, Sichuan University of Science & Engineering, 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 Mrs. Yu Liu, Doctor of Science Program in Technical Education (Vocational Education) Rajamangala University of Technology Thanyaburi, who has been working on the dissertation titled "Blended learning engagement evaluation system for university in China". under the supervision of Assistant Professor Dr. Thosporn Sangsawang. 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.

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Yours sincerely,

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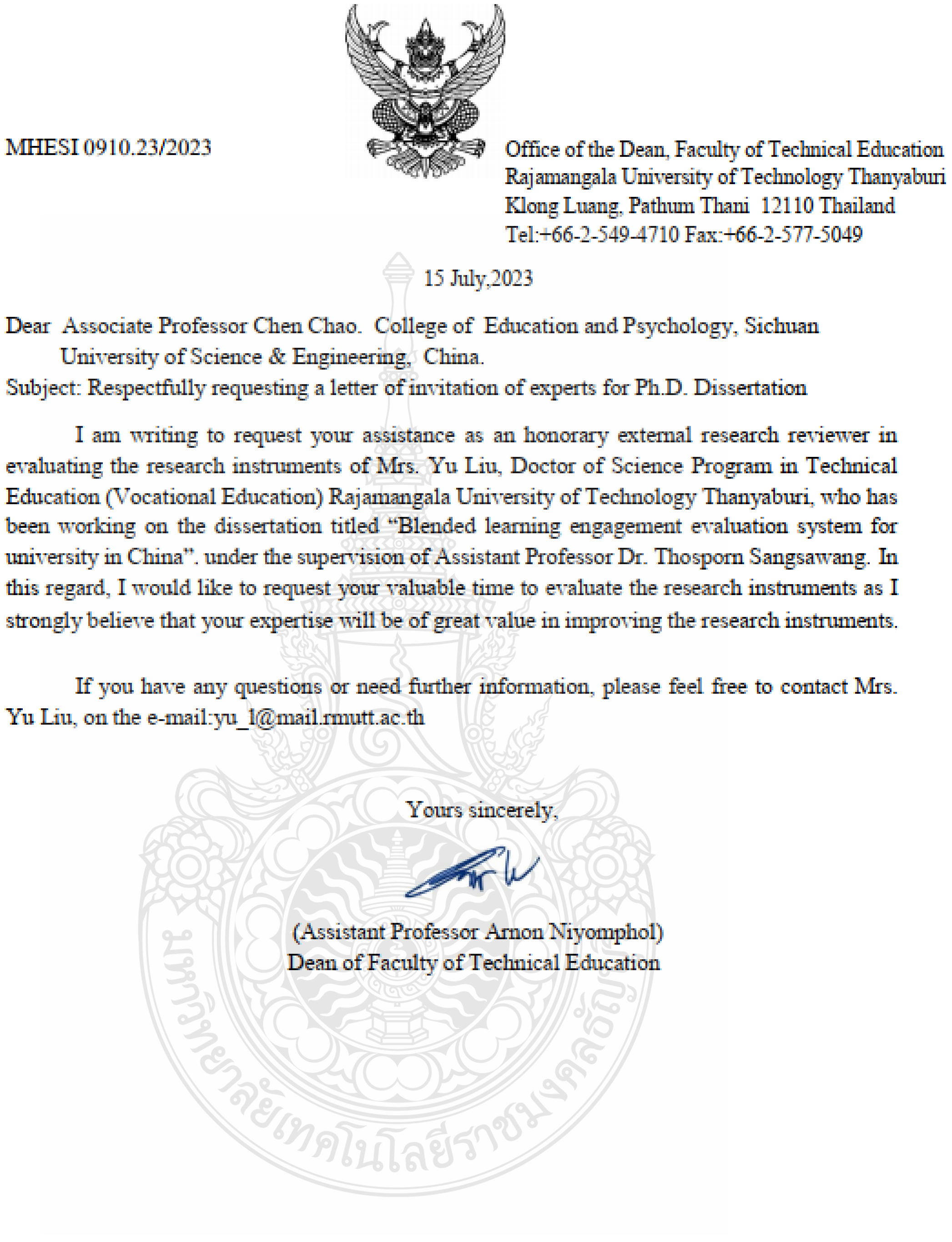
Dean of Faculty of Technical Education



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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Associate Professor Chen Chao. College of Education and Psychology, Sichuan
University of Science & Engineering, China.
Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

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Yours sincerely,

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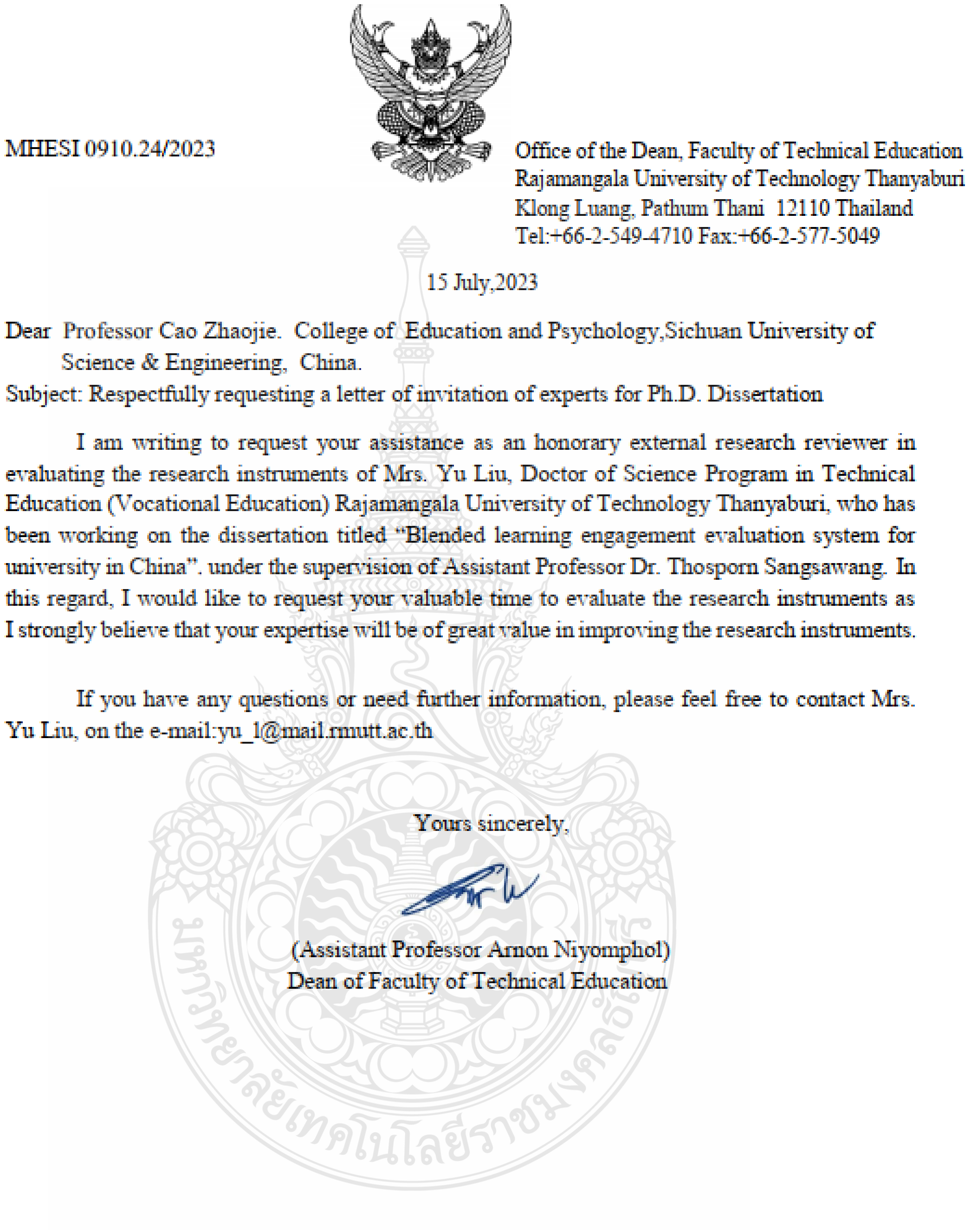
Dean of Faculty of Technical Education



MHESI 0910.24/2023

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Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

Dear Professor Cao Zhaojie. College of Education and Psychology,Sichuan University of Science & Engineering, China.

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

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Yours sincerely,

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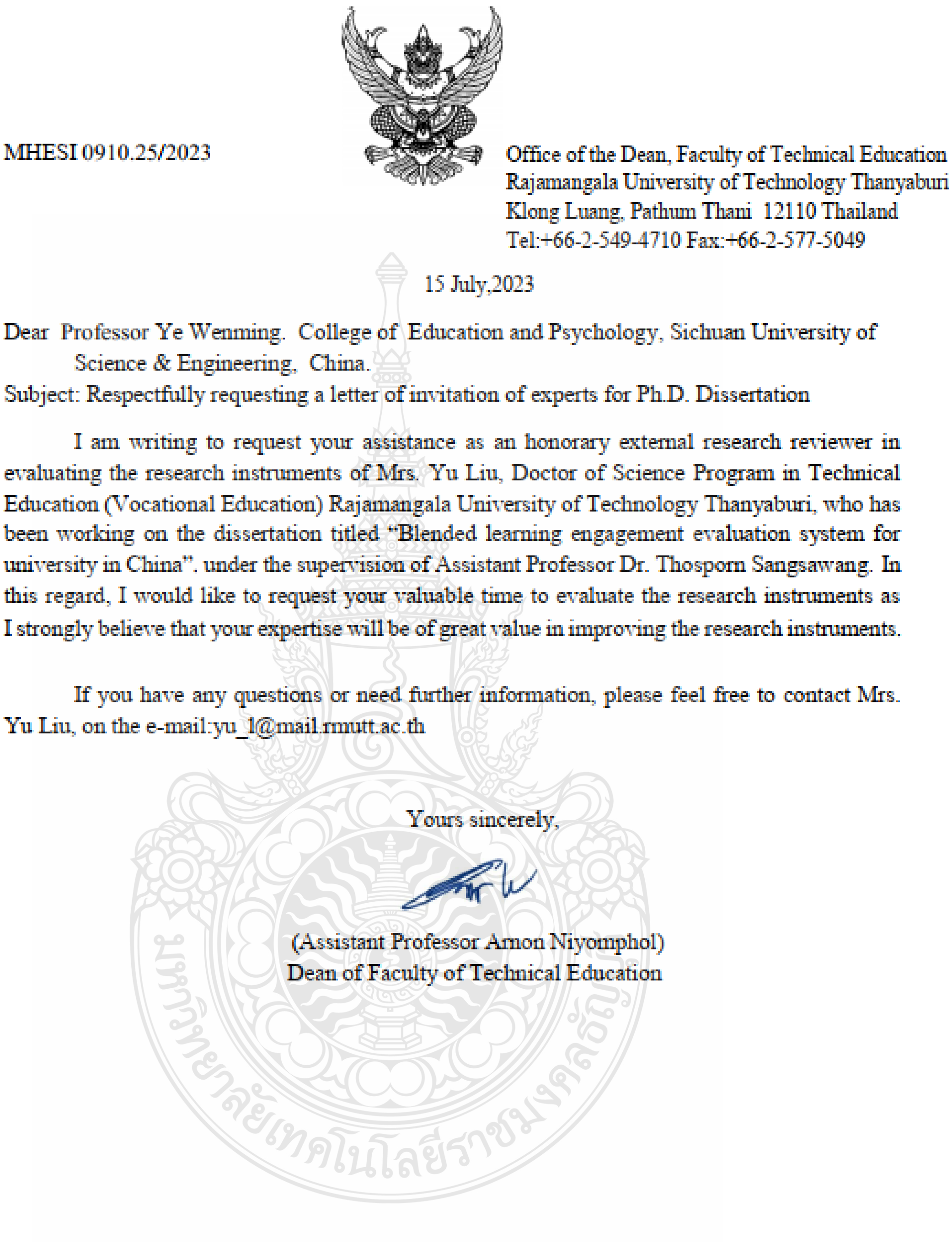

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Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

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

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Yours sincerely,

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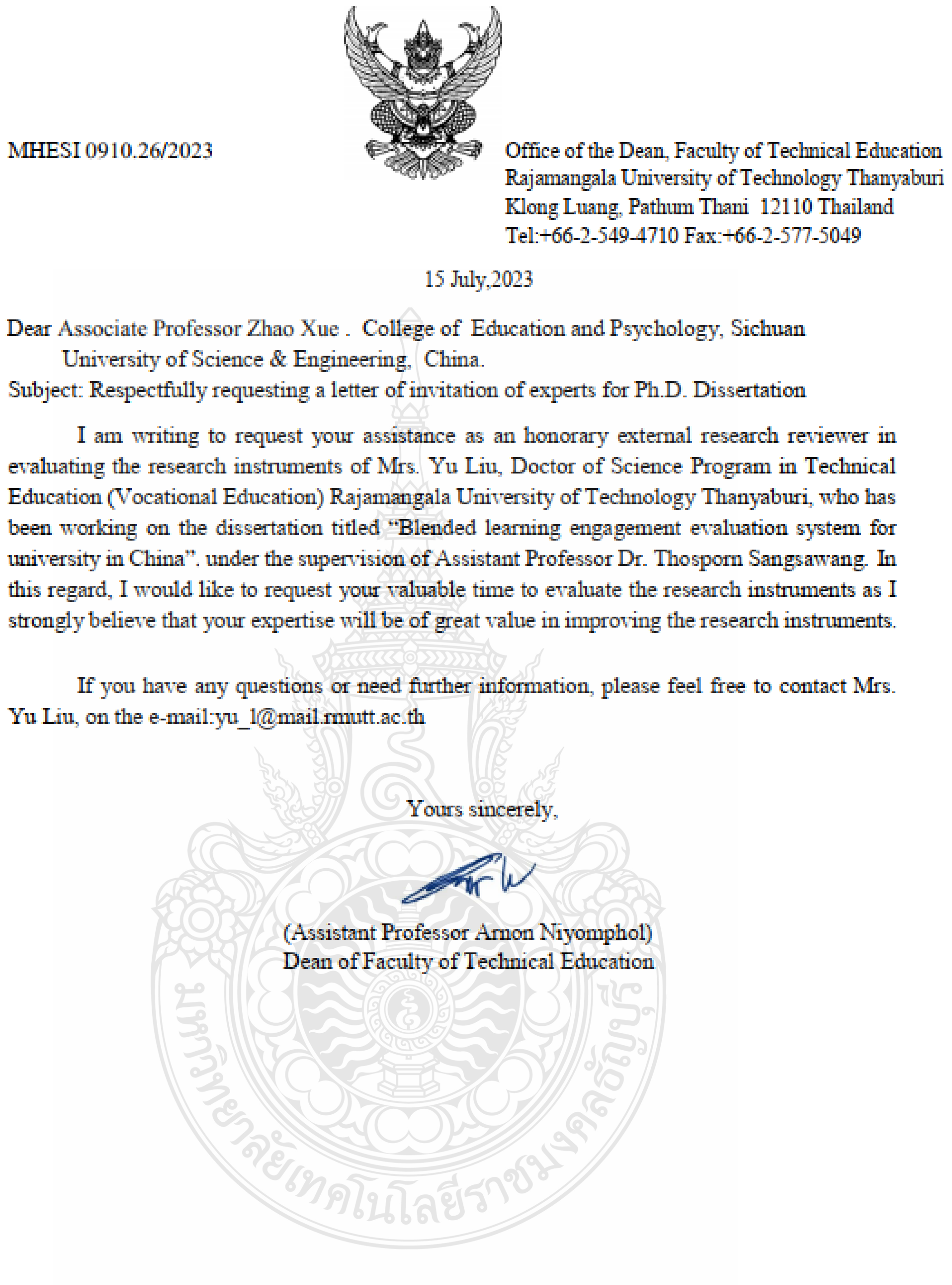
Dean of Faculty of Technical Education



MHESI 0910.26/2023

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Rajamangala University of Technology Thanyaburi
Klong Luang, Pathum Thani 12110 Thailand
Tel:+66-2-549-4710 Fax:+66-2-577-5049

15 July,2023

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University of Science & Engineering, China.
Subject: Respectfully requesting a letter of invitation of experts for Ph.D. Dissertation

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Yours sincerely,

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

Appendix B

Instruments: I First Round: Brainstorming
Semi-Structured Interviews

Semi-Structured Interviews Question

Please use "√" behind the agreed indicators, or you can write in the following box if you have other suggestions

Question	Indicators	Option	Suggestion
1. What do you think learning engagement consists of?	Behavioral engagement		
	Emotional engagement		
	Cognitive engagement		
	Social engagement		
2. What indicators do you think can be considered in behavioral engagement	Effort		
	Focus		
	Attendance		
	Attempt		
	Completing assignments		
	Positive behavior		
	Action		
	Confidence		
	Participation		
	Interaction		
	Seeking help from teachers or peers		
	Taking responsibility		
	Opportunities or challenges		
	Developing a variety of skills		
	Learning performance		
	Metacognitive strategies		
	Supporting and encouraging peers		

	Interaction(with peers,teachers,content,technology)		
	Study habits		
	Trying feedback		
	Engaging in discussion topics		
	Self-evaluation and reflection		
	Setting learning goals		
	Task time		
	Evasion		
	Reaction		
	Persistence		
3. What indicators do you think can be considered in Cognitive engagement	Knowledge integration		
	Critical thinking		
	Self-directed time		
	Innovative thinking		
	Argumentation		
	Induction		
	Academic Challenges		
	Reflection		
	Summarization and Induction Ability		
	Peer learning		
	Rational decision-making		
	Self-efficacy		
	Learning strategies		
	Self-monitoring of Learning		
	Perceived teacher support		
	Input Method		

	Memory/recall		
	Analysis		
4. What indicators do you think can be considered in emotional engagement	Enthusiasm		
	Sense of belonging		
	Curiosity		
	Relevance		
	Interest		
	Happiness		
	Emotional attitude		
	Appreciation		
	Emotional transfer		
	Cognitive reappraisal		
	Desire for success		
	Reward		
	Value		
5. What metrics do you think can be considered in social engagement?	Online attendance rate		
	Discussion participation level		
	Collaborative project engagement level		
	Self-directed learning time		
	Social interaction tool usage rate		
	Project completion rate		
	Interaction feedback time		

Appendix C.

Instruments: Second Round:

Questionnaire I

Faculty of Technical Education
Rajamangala University of Technology Thanyaburi (RMUTT)
39 Moo 1,Rangsit-Nakhon Nayok Road
Klong Hok, Khlong Luang, Pathum Thani
Postal Code 12110, Thailand
Date:

Dear

My name is Mrs Yu Liu. The researcher is a Ph.D. student in the Vocational Education Program in the Faculty of Technical Education of the Rajamangala University of Technology Thanyaburi, RMUTT. The research working on The dissertation entitled: *Blended learning engagement evaluation system for university in China.* The research is in the process of developing the research tools and collecting the data. Seventeen experts will be interviewed in four rounds to collect data using the Delphi technique. First, semi-structured interviews were employed, and data were analyzed using content analysis. Then the results were used to develop the rating scale questionnaires, which will be used for collecting data in the second and third rounds. The second and third rounds aim to confirm the opinions and answers provided by those experts to explore the conclusions and the agreement among experts. Translation.These are essential for the indicators and will be used in the assessment system for blended learning implementation.

This questionnaire was constructed based on the content analysis of the first round. As a result, all experts are kindly asked to please answer the questionnaire. The data obtained will be analyzed by Mean values, standard deviation, and coefficient of variation. The opinions and answers will be kept secret, and the results will be reported as a whole group.

To respond appropriately to the questionnaire, consider and provide the numbers *1, 2, 3, 4,* and *5* to each item for approval, while five is the highest and one is the lowest.

Thank you very much for your kind co-operation.

Your sincerely,

Mrs. Yu Liu

Questionnaire I

Development of a new Learning engagement evaluation system model

Instructions:

1) Please tick (/) in each blank according to your level of opinion.

2) If you think of blended learning engagement in the evaluation system, and in the model each indicator needs to be corrected, the researcher would like to adjust or improve this questionnaire with the greatest thanks.

Level 1 indicators	Opinion				
	5	4	3	2	1
Behavioral Engagement					
Cognitive Engagement					
Affective Engagement					
Your comments on the amendments to the above sections					

Level 2 indicators	Opinion				
	5	4	3	2	1
Participate					
Focus					
Interaction					
Persistence					
Self-monitoring					
Self-Management					
Learning Strategies					
Sense of Belonging					
Emotional Attitudes					
Internal Support					

External Support					
Your comments on the amendments to the above sections					

Level 3 indicators	Opinion				
	5	4	3	2	1
Number of logins to online platforms					
Amount of online tasks completed					
Number of class discussions					
Video learning time					
Amount of class tasks completed					
Peer interaction					
Active interaction					
Teacher-student interaction					
Overcoming difficulties					
Online Task Persistence					
Maintaining high engagement in class					
Class learning time					
Setting clear goals and requirements					

Self-assessment and reflection					
Use of learning tools					
Learning resource					
Time management					
Autonomous time					
Cognitive strategies					
Metacognitive strategies					
Self-identity					
Teacher-student identity					
Habit					
Interest					
Sense of accomplishment					
Learning motivation regulation					
Emotion management					
Self-encouragement					
Coercion					
Reward					
Your comments on the amendments to the above sections					

Appendix D.

Instruments: Third Round: QuestionnaireII

Faculty of Technical Education
Rajamangala University of Technology Thanyaburi (RMUTT)
39 Moo 1,Rangsit-Nakhon Nayok Road
Klong Hok, Khlong Luang, Pathum Thani
Postal Code 12110, Thailand
Date:

Dear

My name is Mrs Yu Liu. The researcher is a Ph.D. student in the Vocational Education Program in the Faculty of Technical Education of the Rajamangala University of Technology Thanyaburi, RMUTT. The research working on The dissertation entitled: *Blended learning engagement evaluation system for university in China.* The research is in the process of developing the research tools and collecting the data. Seventeen experts will be interviewed in four rounds to collect data using the Delphi technique. First, semi-structured interviews were employed, and data were analyzed using content analysis. Then the results were used to develop the rating scale questionnaires, which will be used for collecting data in the second and third rounds. The second and third rounds aim to confirm the opinions and answers provided by those experts to explore the conclusions and the agreement among experts. Translation.These are essential for the indicators and will be used in the assessment system for blended learning implementation.

This questionnaire was constructed based on the content analysis of the first round. As a result, all experts are kindly asked to please answer the questionnaire. The data obtained will be analyzed by Mean values, standard deviation, and coefficient of variation. The opinions and answers will be kept secret, and the results will be reported as a whole group.

To respond appropriately to the questionnaire, consider and provide the numbers *1, 2, 3, 4,* and *5* to each item for approval, while five is the highest and one is the lowest.

Thank you very much for your kind co-operation.

Your sincerely,

Mrs. Yu Liu

Questionnaire II

Development of a new Learning engagement evaluation system model

Instructions:

1) PPlease tick (/) in each blank according to your level of opinion.
2) If you think the stages of the teaching-learning procedure, components, and models of each theory need to be corrected, the researcher would like to adjust or improve this questionnaire with the greatest thanks.

Level 2 indicators	Opinion				
	5	4	3	2	1
Participate					
Focus					
Interaction					
Persistence					
Self-monitoring					
Self-Management					
Learning Strategies					
Sense of Belonging					
Emotional Attitudes					
Emotion management					
Your comments on the amendments to the above sections					

Level 3 indicators	Opinion				
	5	4	3	2	1
Number of logins to online platforms					
Amount of online tasks completed					
Number of class discussions					
Classroom Attendance Rate					
Video Quantity per Unit Time					
Video learning time					
Amount of class tasks completed					
Peer interaction					
Active interaction					
Teacher-student interaction					
Overcoming difficulties					
Online Task Persistence					
Maintaining high engagement in class					
Setting clear goals and requirements					
Self-assessment and reflection					
Use of learning tools					
Learning resource					

Time management					
Cognitive strategies					
Metacognitive strategies					
Self-identity					
Teacher-student identity					
Habit					
Interest					
Sense of accomplishment					
Learning motivation regulation					
Emotion management					
Your comments on the amendments to the above sections					

Appendix E.

Instruments: Fouth Round:

QuestionnaireIII

Questionnaire III

Development of a new Learning engagement evaluation system model

Instructions:

1) Please tick (/) in each blank according to your level of opinion.
2) If you think the stages of the teaching-learning procedure, components, and models of each theory need to be corrected, the researcher would like to adjust or improve this questionnaire with the greatest thanks.

No.	Indicator	Yes Response Percentage	No Response Percentage	Unsure Response Percentage
a.Behavioral Engagement				
1	Participate			
1.1	Number of Online PlatformLogins			
1.2	Online Platform Task Completion			
1.3	Frequency of Answering Questions In Class			
1.4	Classroom Attendance			
2	Focus			
2.1	The Amount of Video Played Per Unit time			
2.2	Amount of Classroom Tasks Completed			
2.3	Classroom Performance			
3	Interaction			
3.1	Discussion Popularity On Online Platforms			

3.2	Peer Reviews and Feedback
3.3	Teacher-Student Interaction
4	Persistence
4.1	Overcome Difficulties
4.2	Online Task Persistence
4.3	Maintaining a High Level Of Engagement In The Classroom
5	Self-monitoring
5.1	Clarify Goals and Requirements
5.2	Self-evaluation and reflection
5.3	Learning Environment Adjustment

b.Cognitive Engagement

1	Depth of thinking
1.1	Logic and Critical Thinking
1.2	Creative Thinking and Problem Solving
1.3	Interdisciplinary Thinking and Associations
2	Learning Strategies
2.1	Summarization and Induction Ability
2.2	Self-test and Rhetorical Questions

c.Emotinal Engagement

1	Self Worth
1.1	Identity
1.2	Sense of Belonging
2	Emotional Experience

2.1	Sense of Accomplishment
2.2	Interest
3	Emotional Regulation
3.1	Cognitive Reappraisal
3.2	Emotional Transfer

Appendix F.

Instruments:AHP hierarchy analysis calculates weights:

Questionnaire IV

Questionnaire Ⅳ

Design the weight of the blended learning engagement

Instructions:

After sorting out and revising the opinions of the two rounds of experts, the evaluation system of blended learning engagement is basically determined.

The judgment matrix is constructed according to the level of the indicators. Please make a pairwise comparison of the judgment matrix and score according to the degree of importance.

Filling instructions: compare the horizontal index with the vertical index, and judge the relative importance of the two. The meaning of the value is as follows:

Scale Meaning of Judgement Matrix

Scale	Meaning
1	Two elements have the same importance to an attribute
3	For one attribute, one element is slightly more important than another element
5	For one attribute, one element is significantly more important than the other element
7	For one attribute, one element is much more important than another element
9	For one attribute, one element is more important than another
2, 4, 6, 8	The significance is between the anterior and posterior scales
1/bi	Represents an anti-comparison of the two elements

Level 1 indicators judgment matrix

Indicators	Behavioral engagement B1	Cognitive Engagement B2	Affective Engagement B3
Behavioral engagement B1	1		
Cognitive Engagement B2		1	
Affective Engagement B3			1

Level 2 indicators judgment matrix

Behavioral engagement B1	Participate C1	Focus C2	Interaction C3	Persistence C4	Self-monitoring C5
Participate C1	1				

Focus C2		1			
Interaction C3			1		
Persistence C4				1	
Self-monitoring C5					1

Cognitive EngagementB2	self-management C6	learning strategy C7
self-management C6	1	
learning strategy C7		1

Affective Engagement B3	Sense of Identity C8	Emotional Attitude C9	Emotional Adjustment C10
Sense of Identity C8	1		
Emotional Attitude C9		1	
Emotional AdjustmentC10			1

Participate C1	Online platform login times D1	Amount of online tasks completed D2	Number of class discussions: D3	Class attendance rate D4
Online platform login times D1	1			
Amount of online tasks completed D2		1		
Number of class discussions: D3			1	
Class attendance rate D4				1

Focus C2	Video volume per unit time: D5	Class task completion amount D6	Classroom behavior performance D7
Video volume per unit time: D5	1		
Class task completion amount D6		1	
Classroom behavior performance D7			1

Interaction C3	Peer Interactive D8	Active Interactive D9	Teacher-student interaction D10
Peer Interactive D8	1		
Active Interactive D9		1	
Teacher-student identityD10			1

Level 3 indicators judgment matrix

Persistence C4	Overcome the difficulties D11	Online task adherence to D12	Classroom high input is maintained D13
Overcome the difficulties D11	1		
Online task adherence to D12		1	
Classroom high input is maintained D13			1

Self-monitoring C5	Identify the objectives and requirements of D14	Self-evaluation and reflection D15	Learning tools were performed using D16
Identify the objectives and requirements of D14	1		

Self-evaluation and reflection D15		1	
Learning tools were performed using D16			1

Self-management C6	Learning Resource Management D17	Time management, D18
Learning Resource Management D17	1	
Time management, D18		1

learning strategy C7	Cognitive strategy D19	The metacognitive strategy D20
Cognitive strategy D19	1	
The metacognitive strategy, D20		1

Sense of Identity C8	Self-identity D21	Teacher-student identity D22
Self-identity, D21	1	
Teacher-student identity D22		1

Emotional Attitude C9	Habit D23	Interest D24	Sense of accomplishment D25
Habit D23	1		
Interest D24		1	
Sense of accomplishment D25			1

Emotional Adjustment C10	Learning motivation regulationD26	Emotion management D27
Learning motivation regulation D26	1	
Emotion management D27		1

Appendix G.

Instruments: Resolution and Report:

Questionnaire V

Questionnaire V

Development of a new Learning engagement evaluation system model

Instructions:

1) Please tick (/) in each blank according to your level of opinion.
2) If you think the stages of the teaching-learning procedure, components, and models of each theory need to be corrected, the researcher would like to adjust or improve this questionnaire with the greatest thanks.

Level 1	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Behavioral Engagement（0.568）			
Cognitive Engagement（0.1914）			
Emotional Engagement（0.2407）			

Level 2	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Participate(0.0787)			
Focus（0.1949）			
Interaction（0.0838）			
Persistence（0.0684）			
Self-monitoring（0.1422）			
Depth of thinking（0.0626）			
Learning Strategies(0.1288)			
Self Worth(0.1270)			
Emotional Experience(0.0825)			
Emotion Regulation(0.0312)			

Level 3	Confirmation (Percentage)	Disconfirmation (Percentage)	Reject (Percentage)
Number of online platform logins(0.0307)			
Online platform task completion(0.0230)			
Frequency of answering questions in class(0.0153)			
classroom attendance(0.0097)			
The amount of video played per unit time(0.0264)			

Amount of classroom tasks completed(0.0976)
Classroom performance(0.0709)
Discussion popularity on online platforms(0.0391)
Peer Reviews and Feedback(0.0263)
Teacher-student interaction(0.0184)
overcome difficulties(0.0115)
Online Task Persistence(0.0362)
Maintaining a high level of engagement in the classroom(0.0207)
Clarify goals and requirements(0.0389)
Self-evaluation and reflection(0.0214)
Learning environment adjustment(0.0818)
Logic and Critical Thinking(0.0211)
Creative Thinking and Problem Solving(0.0302)
Interdisciplinary Thinking and Associations(0.0113)
Summarization and Induction Ability(0.0662)
Self-test and Rhetorical Questions(0.0626)
Identity(0.0966)
Sense of Belonging(0.0304)
Sense of Accomplishment(0.0192)
Interest(0.0633)
Cognitive Reappraisal(0.0066)
Emotional Transfer(0.0245)

Appendix H.

Questionnaire VI

Questionnaire Ⅵ

Application of a new learning engagement evaluation system

Instructions:

1) Please tick (/) in each blank according to your level of opinion.
2) If you think of blended learning engagement in the evaluation system, and in the model each indicator needs to be corrected, the researcher would like to adjust or improve this questionnaire with the greatest thanks.

Level 1 indicators	Level 2 indicators	Level 3 indicators	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Behavioral Engagement	Participate	Number of online platform logins					
		Online platform task completion					
		Frequency of answering questions in class					
		classroom attendance					
	Focus	The amount of video played per unit time					
		Amount of classroom tasks completed					
		Classroom performance					
	Interaction	Discussion popularity on online platforms					
		Peer Reviews and Feedback					

		Teacher-student interaction
	Persistence	Overcome Difficulties Online Task Persistence Maintaining a high level of engagement in the classroom
	Self-monitoring	Clarify goals and requirements Self-evaluation and reflection Learning environment adjustment
Cognitive Engagement	Depth of thinking	Logic and Critical Thinking Creative Thinking and Problem Solving Interdisciplinary Thinking and Associations
	Learning Strategies	Summarization and Induction Ability Self-test and Rhetorical Questions

Emotional Engagement	Self Worth	Identity
		Sense of Belonging
	Emotional Experience	Sense of Accomplishment
		Interest
	Emotional Regulation	Cognitive Reappraisal
		Emotional Transfer

Appendix I.

Judgment Matrix Calculation

The process of calculating the weights of the evaluation system using the AHP method is as follows:

Table 1 B1-B3 Judgment Matrix

Indicator	Behavioral engagement B1	Cognitive EngagementB2	Affective Engagement B3
Behavioral engagement B1	1	2.5882	2.7647
Cognitive Engagement B2	0.3863	1	0.6800
Emotional Engagement B3	0.3617	1.4706	1

Table 2Judgment Matrix CalculationResults

Indicator	Feature vector	Weight	Largest characteristic root	CI
Behavioral engagement B1	1.706	0.5680	3.023	0.011
Cognitive Engagement B2	0.572	0.1914		
Emotional Engagement B3	0.723	0.2407		

Table 3 B1-B3 Judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.023	0.011	0.525	0.022	consistency

Table 4 C1-C5 judgment matrix

Behavioral engagement B1	Participate C1	Focus C2	Interaction C3	Persistence C4	Self-monitoring C5
Participate C1	1	0.3864	0.7392	1.9412	0.4857
Focus C2	2.5882	1	2.1765	4.2353	1.1176
Interaction C3	1.3529	0.4595	1	1.4118	0.4474
Persistence C4	0.5151	0.2361	0.7083	1	0.2429
Self-monitoring C5	2.0588	0.8948	2.2353	4.1176	1

Table 5 C1-C5 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Participate C1	0.693	0.1386	5.241	0.06
Focus C2	1.715	0.3431		
Interaction C3	0.738	0.1476		
Persistence C4	0.602	0.1205		
Self-monitoring C5	1.252	0.2503		

Table 6 C1-C5 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
5.241	0.06	1.11	0.054	consistency

Table 7 C6-C7 judgment matrix

Cognitive Engagement B2	Self-management C6	Learning strategy C7
Self-management C6	1	0.4857
Learning strategy C7	2.0588	1

Because it is a second-order matrix, it cannot be calculated in SPSSPRO software. The formula is used to calculate. The steps are as follows:

(1)Each column of the judgment matrix is normalized, that is, each indicator is divided by the sum of the indicators in its column.

$$\begin{bmatrix} 1 & 0.4857 \\ 2.0855 & 1 \end{bmatrix} \rightarrow \begin{bmatrix} 0.3269 & 0.3269 \\ 0.6731 & 0.6731 \end{bmatrix}$$

(2)After normalization is completed, the elements in each row are summed.

$$\begin{bmatrix} 0.3269 & 0.3269 \\ 0.6731 & 0.6731 \end{bmatrix} \rightarrow \begin{bmatrix} 0.6539 \\ 1.3461 \end{bmatrix}$$

(3) Perform normalization again to obtain the relative weight vector of the matrix .

$$\begin{bmatrix} 0.6539 \\ 1.3461 \end{bmatrix} \rightarrow \begin{bmatrix} 0.3269 \\ 0.6731 \end{bmatrix}$$

Table 8 C6-C7 judgment matrix calculation results

Cognitive EngagementB2	Weight
Self-management C6	0.3269
learning strategy C7	0.6731

Table 9 C6-C7 judgment matrix calculation results

Cognitive EngagementB2	Weight
Self-management C6	0.3269
learning strategy C7	0.6731

Table 10 C8-C10 judgment matrix

Affective Engagement B3	Sense of Identity C8	Emotional Attitude C9	Emotional Adjustment C10
Sense of Identity C8	1	2.1176	3.1176
Emotional Attitude C9	0.4722	1	3.6471
Emotional AdjustmentC10	0.3208	0.2742	1

Table 11 C8-C10 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI

Sense of Identity C8	1.584	0.5279	3.092	0.046
Emotional Attitude C9	1.028	0.3426		
Emotional AdjustmentC10	0.389	0.1295		

Table 12 C8-C10 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.092	0.046	0.525	0.088	consistency

Table 13 D1-D4 judgment matrix

Participate C1	Online platform login times D1	Amount of online tasks completed D2	Number of class discussions: D3	Class attendance rate D4
Online platform login times D1	1	1.1765	2.6471	2.8235
Amount of online tasks completed D2	0.8500	1	1.5882	2.0588
Number of class discussions: D3	0.3778	0.6296	1	2.1176
Class attendance rate D4	0.3542	0.4857	0.4722	1

Table 14 D1-D4 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Online platform login times D1	1.561	0.3903	4.054	0.018
Amount of online tasks completed D2	1.169	0.2922		
Number of class discussions: D3	0.778	0.1944		
Class attendance rate D4	0.492	0.1231		

Table 15 D1-D4 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
4.054	0.018	0.882	0.02	consistency

Table 16 D5-D7 judgment matrix

Focus C2	Video volume per unit time: D5	Class task completion amount D6	Classroom behavior performance D7
Video volume per unit time: D5	1	0.2656	0.3778
Class task completion amount D6	3.7647	1	1.3529

Classroom behavior performance D7	2.6471	0.7392	1

Table 17 D5-D7 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Video volume per unit time: D5	0.406	0.1353	3	0
Class task completion amount D6	1.502	0.5007		
Classroom behavior performance D7	1.092	0.3640		

Table 18 D5-D7 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3	0	0.525	0	consistency

Table 19 D8-D10 judgment matrix

Interaction C3	Peer Interactive D8	Active Interactive D9	Teacher-student interaction D10
Peer Interactive D8	1	1.4118	2.2353
Active Interactive D9	0.7083	1	1.3529
Teacher-student identityD10	0.4474	0.7392	1

Table 20 D8-D10 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Peer Interactive D8	1.399	0.4664	3.003	0.001
Active Interactive D9	0.941	0.3136		
Teacher-student identityD10	0.66	0.2200		

Table 21 D8-D10 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.003	0.001	0.525	0.003	consistency

Table 22 D11-D13 judgment matrix calculation results

Persistence C4	Overcome the difficulties D11	Online task adherence to D12	Classroom high input is maintained D13	Weight
Overcome the difficulties D11	1	0.2982	0.5862	0.1676
Online task adherence to D12	3.3529	1	1.6471	0.5292
Classroom high input is maintained D13	1.7059	0.6071	1	0.3032

Table 23 D11-D13 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Overcome the difficulties D11	0.503	0.1676	3.003	0.002
Online task adherence to D12	1.588	0.5292		
Classroom high input is maintained D13	0.909	0.3032		

Table 24 D11-D13 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.003	0.002	0.525	0.003	consistency

Table 25 D14-D16 judgment matrix

Self-monitoring C5	Identify the objectives and requirements of D14	Self-evaluation and reflection D15	Learning tools were performed using D16
Identify the objectives and requirements of D14	1	2.1765	0.3938
Self-evaluation and reflection D15	0.4595	1	0.3091
Learning tools were performed using D16	2.5394	3.2353	1

Table 26 D14-D16 judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI

Identify the objectives and requirements of D14	0.821	0.2736	3.032	0.016
Self-evaluation and reflection, D15	0.452	0.1508		
Learning tools were performed using D16	1.727	0.5756		

Table 27 D14-D16 judgment matrix passed the consistency test

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.032	0.016	0.525	0.03	consistency

Due to the second-order judgment matrix, the calculation results have been described above, and the calculation weights of the following second-order judgment matrix will not be repeated.

Table 28 D17-D18judgment matrix calculation results

Self-management C6	Learning Resource Management D17	Time management, D18	Weight
Learning Resource Management D17	1	0.3091	0.2361
Time management, D18	3.2353	1	0.7639

Table 29 D19-D20judgment matrix calculation results

Learning strategy C7	Cognitive strategy D19	The metacognitive strategy D20	Weight
Cognitive strategy D19	1	1.0588	0.5143
The metacognitive strategy, D20	0.9445	1	0.4857

Table 30 D21-D22judgment matrix calculation results

Sense of Identity C8	Self-identity D21	Teacher-student identity D22	Weight
Self-identity, D21	1	3.1765	0.6197
Teacher-student identity D22	0.3148	1.0000	0.2394

Table 31 D23-D25judgment matrix calculation results

Emotional Attitude C9	Habit D23	Interest D24	Sense of accomplishment D25	Weight
Habit D23	1	0.3036	2.7647	0.2491
Interest D24	3.2941	1	4.5294	0.6365
Sense of accomplishment D25	0.3617	0.2208	1	0.1144

Table 32 D23-D25judgment matrix calculation results

Indicators	Feature vector	Weight	Largest characteristic root	CI
Habit D23	0.747	24.909	3.054	0.027
Interest D24	1.91	63.654		
Sense of accomplishment D25	0.343	11.437		

Table 33 D23-D25judgment matrix calculation results

Largest characteristic root	CI	RI	CR	Consistency Test Results
3.054	0.027	0.525	0.052	consistency

Table 34 D26-D27 judgment matrix calculation results

Emotional AdjustmentC10	Learning motivation regulationD26	Emotion management D27	Weight
Learning motivation regulation D26	1	0.2698	0.2125

Biography

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

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....
(Ms.Yu Liu)