STUDENT LEARNING ENGAGEMENT MODEL DEVELOPMENT FOR BLENDED TEACHING MODELS BASED ON SMALL PRIVATE ONLINE COURSE DIGITAL PLATFORMS, LIAONING PROVINCE, CHINA

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Thesis Title Student Learning Engagement Model Development for Blended Teaching Models Based on Small Private Online Course Digital Platforms Liaoning Province China

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Abstract

This study aimed to develop and validate a student learning engagement model for SPOC-based blended teaching in marketing courses and to examine its effectiveness. A three-phase research design was adopted. First, a questionnaire was developed through literature review, expert consultation, IOC validation, and pilot testing. Second, 895 valid responses from 1,080 undergraduate students at six universities in Liaoning Province were analyzed using factor analysis and structural equation modeling. Third, an eight-week experiment involving 71 students was conducted.

The results identified four dimensions of learning engagement:

1. Behavioral, cognitive, emotional, and interactional engagement.

2. The final model showed good fit, with $\chi^2/df = 3.24$, CFI = 0.975, and RMSEA = 0.058.

3. The experimental group outperformed the control group, and course attainment increased by 18.6%, confirming the model's validity and practical value.

Keywords: SPOC blended teaching, learning engagement model, structural equation modeling, emotion-driven intervention, digital education management

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Introduction

Rationale

With the rapid development of modern educational technology and information technology, as well as the widespread use of the Internet, innovative teaching models such as the Small Private Online Course (SPOC) have gradually been applied in higher education and have shown positive effects in teaching practice. At the same time, SPOC-based online and offline blended teaching, designed according to course characteristics, has been increasingly used to improve teaching effectiveness, enhance student participation, meet personalized learning needs, optimize the use of teaching resources, and cultivate students' practical abilities. Therefore, SPOC-based blended teaching has become an important topic in higher education research.

However, SPOC teaching involves teaching activities in two teaching scenarios, online and offline. The traditional classroom teaching evaluation method has weak formative evaluation ability for students and is difficult to support the evaluation needs of SPOC teaching effects. Learning behavior Engagement is one of the core elements of learning behavior, which has a key impact on the learning effect and academic performance of college students. As one of the key variables in the learning process, it is gradually becoming a core means and new perspective for measuring learning effects. Therefore, in the process of constructing a teaching evaluation system, it is necessary to take learning behavior Engagement as the observation point, deeply analyze the changes in students' learning behavior Engagement, help teachers grasp students' learning dynamics at any time, and further effectively implement intervention, so as to improve the effect of hybrid SPOC teaching. This study combines the talent training goals of colleges and universities, the characteristics of marketing courses, and the necessity of SPOC teaching in marketing courses to form a highly targeted hybrid teaching model for marketing

courses, and further constructs a teaching evaluation model based on learning engagement. On this basis, the structural equation model (SEM) is introduced as an analysis tool to systematically verify the relationship between learning behavior Engagement, teaching resource utilization, student participation and teaching effect. Through the SEM model, the impact of the SPOC teaching model on students' learning behavior can be more comprehensively evaluated, and the causal relationship between the variables can be revealed, thereby providing a scientific basis for the optimization of the teaching model.

Taking a specific classroom as a carrier for analysis and explanation, this study aims to improve the application effect of SPOC teaching in the "Marketing" course through practical exploration of the "Marketing" course, hoping to play a certain role in promoting the innovative research of modern education and teaching methods, and provide some useful reference for the future teaching reform of higher education.

Research Question

How to develop an effective assessment model to evaluate student learning engagement in a blended learning model based on a small private online course SPOC digital platform?

Objectives

1. To survey the current state of student learning engagement in blended teaching based on the SPOC digital platform.

2. To develop model for assessing student learning engagement in blended teaching based on the SPOC digital platform.

3. To evaluate the effectiveness of developing a student learning engagement model for blended teaching based on the SPOC digital platform.

Research Hypothesis

Under the current education model, teachers and students already have basic digital literacy and can flexibly use the SPOC digital teaching platform for teaching, and in the context of the SPOC digital platform, blended teaching shows its unique advantages and effectively enhances students' learning participation.

Scope of the Research

Population and the Sample Group

Population

The research object of this study consists of two parts: undergraduate students majoring in marketing and related disciplines at six universities in Liaoning Province, and experts and scholars related to marketing majors at these universities.

Among them, there are 1,080 undergraduate students majoring in marketing and related disciplines. The expert group consists of 35 experts and scholars who have more than 10 years of teaching and research experience in marketing, business administration, financial management and other related professional fields, and all of them have doctoral or master’s degrees, and most of them are professors or associate professors. These experts are enthusiastic about teaching reform and research, and actively participate in the project consulting work.

The Sample Group

The sample group was organized according to the three phases of the research. A total of 1080 undergraduate students participated in the large-scale survey phase, and 895 valid questionnaires were collected for model development; 71 students participated in the experimental phase; and 5 experts were selected from the expert group to form an expert advisory group and an IOC validation group.

Phase 1: In the first phase, 1080 undergraduate students from marketing and related majors at six universities were selected as the survey sample. After data collection, 895 valid questionnaires were collected. In this phase, 5 experts were selected from 35 experts and scholars to review the questionnaires and conduct IOC validation to ensure the correctness, completeness, and content validity of the

questionnaires. In addition, three rounds of pre-surveys were conducted on 71 students before the formal survey to improve the clarity and reliability of the questionnaires.

Phase 2: In the second phase, model development was based on the 895 valid questionnaires collected in the first phase. This data was used for factor analysis and structural equation modeling to construct a model of student learning engagement. During the tool refinement process, the same 5 experts continued to serve on the expert advisory group and the IOC validation group.

Phase 3: In Phase Three, 71 students were selected from the Marketing major at Liaoyang Branch of Shenyang University of Technology. To evaluate the effectiveness of the developed learning engagement model, they were randomly divided into two groups: a control group of 35 students and an experimental group of 36 students.

The Variables

Teaching Method Effectiveness

Capacity of students to participate in learning

Digital pedagogical literacy for teachers

Learning Environment

Contents of the Research

This topic mainly studies the following aspects:

1. Combining multiple systems to explore the internal structural relationship of constructing the model and get a feasible evaluation model of college students' SPOC learning engagement.

2. In the process of modeling, designing and completing tools suitable for evaluating college students' SPOC learning engagement.

3. On the basis of the model, analyze and elaborate the correlation between college students' engagement in learning based on SPOC platform and their academic performance based on actual cases.

Time

The study will be conducted during the first semester of the 2025 academic year (April 2025 - April 2026).

Place

Shenyang University of Technology Liaoyang Branch Liaoning Province

Advantages

1. Understand the current status of students' learning participation in hybrid teaching based on SPOC digital platform.

2. Improve students' learning participation and improve students' grades through the hybrid teaching model of SPOC digital platform.

3. Improve students' learning participation in the hybrid teaching model based on SPOC digital platform.

Definition of Terms

Blended teaching mode

The hybrid teaching mode is a teaching method that organically combines traditional face-to-face teaching with online teaching. It is not a simple addition of online resources and offline classes, but a careful design of the teaching process based on teaching objectives, teaching content and student learning characteristics, so that online and offline teaching links complement each other and promote each other. The online teaching part uses online learning platforms, teaching software and other tools to provide students with rich learning resources, such as electronic textbooks, teaching videos, online tests, discussion areas, etc. Students can arrange online learning according to their own time and learning progress, and conduct knowledge preview, review and expansion learning. Offline teaching focuses on teacher-student Interactional, practical operation and in-depth knowledge explanation and discussion. Teachers can focus on answering common questions in students' online learning process, organize group discussions, case analysis and other activities, and cultivate students' critical thinking and practical ability. This model

breaks the limitations of time and space of traditional teaching, and gives full play to the advantages of rich online teaching resources, strong learning autonomy, good offline teaching interactivity, and timely practical guidance, creating a more flexible, efficient and personalized learning environment for students.

Small Private Online Course (SPOC) platform

The Small Private Online Course (SPOC) platform is a digital teaching platform that integrates online learning resources with traditional face-to-face classroom teaching. It mainly serves on-campus students and may also allow authorized off-campus learners to access selected courses. Through the platform, teachers can provide videos, reading materials, assignments, quizzes, and discussion activities before or after class, while students can complete preview, review, and interactive learning tasks online. In classroom teaching, teachers can then focus on explaining key and difficult points, organizing discussions, and providing targeted guidance. The platform also supports automatic correction, learning progress tracking, statistical reports, and personalized learning support. In this study, the SPOC platform refers to the digital platform used to support online and offline blended teaching in marketing courses.

Blended teaching content

Blended teaching content refers to teaching materials that combine traditional offline teaching resources with online digital resources in blended teaching. It includes online resources (such as electronic textbooks, teaching videos, online tests, Interactional forums, etc.) and offline resources (such as classroom lectures, practical operations, group discussions, etc.). This content design aims to meet the learning needs of different students through diversified learning materials and activities, while giving full play to the advantages of online self-learning and offline Interactional teaching, improving teaching effectiveness and students' learning experience.

Blended teaching model

The blended teaching model is a teaching method that combines traditional face-to-face teaching with online teaching. It optimizes online and offline teaching

links so that the two complement and promote each other to achieve more efficient teaching results. The hybrid teaching mode emphasizes the flexible design of teaching processes according to teaching objectives and student needs, giving full play to the richness of online resources and the depth of offline Interactionals, thereby improving students' learning motivation and participation.

Blended teaching assessment model

The Blended Teaching Assessment Model is a structured method for measuring and analyzing students' learning outcomes, learning behaviors, and learning experiences in a blended learning environment. The model usually includes the following core dimensions:

Behavioral Data: Analyze students' learning activities on online platforms, such as video viewing time, test scores, homework completion rate, etc.

Cognitive Performance: Assess students' knowledge mastery and thinking ability through exams, papers, or projects.

Emotional Engagement: Assess students' learning interest, motivation, and satisfaction through questionnaires or learning logs.

Teacher-Student Interactional: Measure the frequency of communication between teachers and students, the quality of Interactional, and the impact on learning outcomes.

This assessment model usually combines quantitative data analysis (such as big data learning analysis, statistical modeling) and qualitative research (such as interviews, classroom observations) for comprehensive evaluation.

Digital technology in education

Digital technology in education refers to the use of modern information technology means such as computers, the Internet, and software tools to enhance and optimize the teaching process. These technologies include learning management systems (LMS), multimedia teaching tools, virtual reality (VR), augmented reality (AR), etc., aiming to break the limitations of time and space through digital means, provide students with a richer and more diverse learning experience, and improve teaching efficiency and quality.

Student engagement assessment model

The Student Engagement Assessment Model is a comprehensive framework for measuring student engagement in a blended learning environment. It is usually divided into three core dimensions:

Behavioral Engagement: Focuses on the degree of student engagement in learning activities, such as attendance, homework submission rate, and frequency of online Interactionals.

Emotional Engagement: Measures students' interest in the course, sense of belonging, and learning motivation, and usually obtains data through questionnaires or interviews.

Cognitive Engagement: Assess the depth of thinking and critical thinking ability of students in the learning process, which can be measured through learning logs, discussion forum analysis, etc.

The model combines learning analytics technology and teaching big data to provide personalized feedback for different student groups to optimize teaching design.

Student learning engagement

Student learning engagement refers to the degree of students' involvement in teaching content and activities in a blended learning environment, reflecting the attention, interest and initiative shown by students in the learning process. It includes online participation (such as accessing learning resources and participating in discussions) and classroom participation (such as group discussions and practical activities). Students with high engagement usually show better learning effects and higher satisfaction, so improving student engagement is an important goal of blended teaching.

Teacher-student Interactional in a hybrid mode

Teacher-student Interactional in a hybrid mode refers to the communication and cooperation between teachers and students through multiple online and offline channels in a hybrid teaching environment. This Interactional method combines the convenience of online platforms (such as discussion areas and video conferences)

with face-to-face communication in offline classrooms, broadening the channels for communication between teachers and students. Through personalized guidance and two-way communication, teacher-student Interactional in a hybrid mode can effectively promote students' in-depth learning and enhance their learning motivation and participation.

Research methodology for blended learning

Refers to the research techniques and methods used to analyze and evaluate the effectiveness of blended teaching models. It mainly includes quantitative research, which quantitatively evaluates teaching effectiveness through questionnaires, online learning data analysis, test score statistics, etc.; qualitative research, which uses interviews, classroom observations, focus groups and other methods to deeply explore students' learning experience and teachers' teaching strategies; experimental research, which verifies the effectiveness of blended teaching by comparing students' learning performance under different teaching models; and mixed methods research, which combines quantitative and qualitative data to provide a more comprehensive perspective for research. The combination of these research methods can deeply understand the advantages and challenges of the blended teaching model and provide scientific data support for optimizing teaching design and practice.

Research Framework

In this study, a model of student learning engagement in a blended learning model applicable to the SPOC digital platform is developed. The whole research process is divided into three stages:

Phase 1: Status quo survey and dimension extraction

In this phase, we first conducted an extensive theoretical study, including a review of relevant literature and an exploration of related theories. We investigated the current state of SPOC teaching and learning and defined the concept of learning engagement. Based on this, we designed a questionnaire to assess student learning engagement and submitted it to 5 experts for consultation. After collecting and

processing the experts' opinions, we revised the questionnaire until a consensus was reached. The same five experts then conducted an IOC validation to ensure content validity.

Three rounds of pre-surveys were carried out with a total of 71 students to further refine the questionnaire items. The final version of the questionnaire was then administered to 1,080 undergraduate students from six universities in Liaoning Province, and 895 valid responses were collected. Through reliability analysis, confirmatory factor analysis, and validity tests, a four-dimensional structure of learning engagement was identified, namely behavioral engagement, cognitive engagement, emotional engagement, and Interactional engagement, comprising 15 measurement items. This phase provided a validated instrument and laid a solid foundation for the subsequent model construction.

Phase 2: Model construction

In the second phase, we used the 895 valid responses from Phase 1 to construct a structural equation model for learning engagement assessment. An initial theoretical model was first specified and then modified through iterative model refinement, resulting in a final model with satisfactory fit indices. The final model revealed a chain mediation structure, with emotional engagement influencing behavioral engagement through cognitive engagement, and Interactional engagement serving as an antecedent of both emotional and cognitive engagement. The output of this phase is a finalized SEM-based learning engagement evaluation model, which provides a theoretical foundation for further empirical applications.

Phase 3: Empirical application

The goal of the third phase is to evaluate the effectiveness of the developed learning engagement model. An 8-week randomized controlled trial was conducted with 71 students randomly assigned to an experimental group (36 students) and a control group (35 students). The experimental group adopted a dashboard-based teaching intervention designed around an emotional activation, cognitive deepening, and behavioral externalization cycle, with three rounds of process evaluation and instructional adjustment. The control group followed the conventional SPOC

teaching procedure. Both groups completed the validated questionnaire as a pre-test and post-test, and a unified final examination was administered at the end of the course. The results showed that the experimental group significantly outperformed the control group in both formative and summative assessments, with course attainment levels improving by 18.6% and emotional engagement accounting for 42% of the mediating effect. Ultimately, we verified the rationality, scientificity, and applicability of the developed model.

Through these three phases of research, we not only constructed a scientific and effective learning engagement assessment model, but also verified its application value in improving students' learning engagement under the blended teaching mode based on the SPOC platform through empirical research. This study provides a useful reference for higher education teaching reform and lays the foundation for future research.

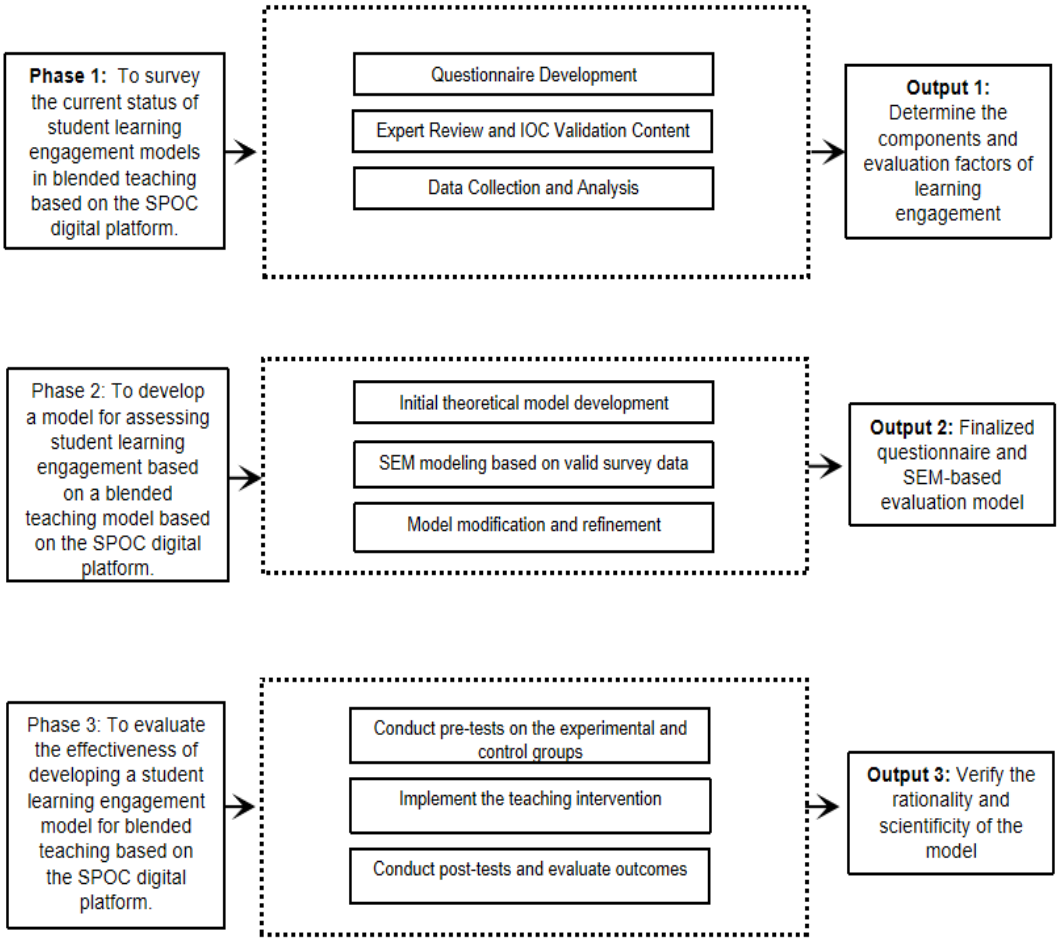

Figure 1.1 Research Framework

Chapter 2

Literature Review

In order to develop a model for evaluating student learning engagement in a blended teaching model with a SPOC digital platform, the researchers conducted the following related studies:

1. Concepts and Characteristics of SPOC-Based Blended Teaching
2. Theoretical Foundations of Student Learning Engagement
3. Dimensions of Student Learning Engagement
4. Practical Studies on Student Learning Engagement
5. Evaluation Tools for Student Learning Engagement
6. Learning Engagement and Learning Effectiveness
7. Student Learning Engagement in SPOC-Based Blended Teaching
8. Related research

The details of these studies are as follows.

Concepts and Characteristics of SPOC-Based Blended Teaching

The SPOC platform teaching mode in the early stage of creation generally adopts a small-scale online course teaching mode. With the continuous development and progress of information technology, most of China's colleges and universities in the implementation process, the more successful SPOC teaching cases, usually for similar majors on campus, to carry out a kind of blended teaching combined with offline classroom and online courses, that is, relying on the SPOC digital platform, directly in the college campus, classroom teaching, the online course as a highly reliable network education resources, such as MOOC video service. Alternatively, it is to utilize online platforms with relevant teaching support functions as well as various special functions such as Interactional, comments, homework, evaluation, and so on, to realize extended teaching. The general process is that the

teacher arranges such online educational resources (such as video footage or Interactional courseware) in the form of homework for students, and then answers the questions assigned by the teacher in the classroom of the lesson, so as to understand what the students have learned about the digital proceeds of the students, and what should be known and should be able to know has not been grasped, and then study together with the students or answer the questions and solve the puzzles in the classroom(Kan, Liu, & Du, 2017). The platform builds online and offline blended teaching, based on the content of online pre-study and teacher guidance, focusing on students' self-discovered knowledge difficulties, and then using classroom Interactional to solve them, and consolidating the online course content and practice exercises. SPOC teaching mode can fully guide students to take the initiative in mixed learning, enhance students' communication ability, make students more obviously recognize their own misconceptions and deficiencies in learning, is one of the current teaching methods of general higher education with remarkable results, as a teaching mode that has gradually developed and matured in recent years, it has considerable application space.

Internationally, most scholars define the core concept of SPOC as a specially developed curriculum with excellent lecturers. A blended approach to online and offline teaching is used, where online students can learn according to their own needs and offline teachers themselves can provide individual instruction (Baggaley, 2014). Yunnan makes SPOC teaching effective, it is necessary to ensure the completion of all the functions of the online platform, but also need to ensure that the MOOC team teaching rigor, professional authority, as well as a wealth of teaching experience, and must have the ability to jump to the classroom (Luo, Sun, & Gu, 2014).

Armando Fox, as a pioneer of the Massive Open Online Course (MOOC), argued that SPOC can further improve the MOOC model by applying high-quality online course resources to smaller and more targeted teaching contexts. Compared with MOOC, SPOC adopts a small-scale teaching format, which enables students to receive more focused learning support and experience a more complete learning

process, thereby avoiding some limitations of MOOC, such as insufficient interaction and low course completion rates (Fox, 2013). Robert Lue of Harvard University also regarded SPOC as an extension of MOOC. He believed that the teaching process and learning resources in SPOC are customized for specific groups of students, which helps overcome the problems caused by the weak integration between MOOC resources and actual classroom teaching, such as low teaching quality and low completion rates (Fox & Patterson, 2013). In conclusion, SPOC can make use of the advantages of MOOC while reducing its limitations, thereby improving teaching quality and course completion rates.

In China, due to the late start of the online education system, there are many international scholars' studies on MOOC and SPOC teaching mode. China's SPOC initially originated from Tsinghua University based on the “Xue tang Online” platform of the two SPOC courses, the SPOC teaching mode to 2014 ten years ago, SPOC has become a lot research on education hotspot. Some famous Chinese scholars adhere to the university's own characteristics, localized exploration of SPOC, the use of SPOC teaching mode to carry out teaching, self-conscious SPOC teaching mode theory and practice has a more in-depth study.

For the theoretical study of SPOC teaching mode, Lv Jingjing (2015) studied the importance of hybrid teaching in open universities on the basis of the advantages of SPOC teaching. Lin Xiaofan et al. (2015) examined the cultivation of innovation ability based on SPOC, focusing on the Interactional between teachers and students in the teaching process. Ding Yonggang, Jin Mengsheng et al. (2017) combined SPOC with the flipped classroom 2.0 teaching mode to ultimately achieve the purpose of promoting students' personalized development. Wang Pengjiao, Cui Can et al. (2018) established a leading SPOC teaching model through the SPOC teaching model and leading teaching in recent years and guided by the construction theory and activity theory, which further enhanced students' independent learning ability and spontaneous problem solve ability. It can be seen that the theoretical research on China's SPOC teaching mode is mainly based on the flipped classroom and online-offline hybrid teaching mode, and fully collects international teaching cases.

In response to the practical research of SPOC teaching mode, SPOC has gathered hotspots of research in the international arena, and some famous Chinese universities and institutions have started to build SPOC digital platforms and courses. Tsinghua University launched the first global SPOC course for MBA in 2014, with open enrollment for students worldwide. Immediately after that, Tianjin University, facing Zhejiang University also began to try SPOC teaching. Zhejiang University established the CNSPOC platform, and cooperated with other universities, students can not only choose courses across schools, but also realize the mutual recognition of students' course credits In the same year, in the Chinese university MOOC platform, Harbin Institute of Technology jointly developed university SPOC courses with ten universities, combined with the characteristics of each university, carried out teaching practice, tried the online and offline hybrid teaching mode, and achieved effective The results have been effective. Professor Wang Pengjiao of Liaoning Normal University puts SPOC teaching design and hybrid design theory, examines the open university, changes the teaching mode of the development university, and improves the quality of teaching (Wang Pengjiao, 2015). Some colleges and universities have innovated the teaching mode by combining SPOC teaching theory with the platform, online and offline hybrid teaching mode, and simplifying the classroom form. This mode not only enhances the learning experience of students, but also improves the effective teaching effect (Chen et al., 2019). Under the SPOC model, students can learn the course content independently through the online platform, while the offline classroom provides more opportunities for teacher-student Interactionals and questions and answers (Huang & Liu, 2020). Recently, the SPOC model has been widely used in higher education, especially in terms of course design and student engagement.

In recent years of educational technology research, the SPOC (Small Private Online Course) blended learning model has received widespread attention for its flexibility and personalized learning support. Li & Zhao (2024) explored in detail the design and practice of the SPOC blended learning model in a basic computer course in their study. It is pointed out that the model provides students with a personalized

learning path through the combination of online independent learning and offline Interactional teaching, enabling students to learn at their own pace. This design not only significantly improves students' learning engagement, but also effectively promotes learning outcomes through targeted learning support and feedback.In addition, Li & Zhao (2024) emphasized that the complementary nature of online and offline activities is a key factor in the success of the SPOC model. The online platform provides rich learning resources and an independent learning environment where students can consolidate their knowledge through videos, quizzes, and online discussions before or after class, while the offline classroom enhances students' comprehension and application skills through teacher-student Interactionals, group discussions, and Q&A sessions. This blended teaching model is particularly suitable for basic computer courses, as it can meet the needs of students with different learning styles and ability levels, while enhancing the overall teaching quality.

It can be seen that China's SPOC teaching practice is mainly carried out for university enterprises, and for more general universities, case studies with rigorous SPOC teaching platforms still lack applicability and need to be further explored; at the same time, China's research perspectives on the SPOC teaching model are also biased towards examining how to utilize the role of SPOC from the perspectives of the school and the platform, but few scholars have been able to At the same time, China's research on SPOC teaching model is also biased towards studying how to play the role of SPOC from the perspective of schools and platforms, but few scholars have been able to systematically study the impact of SPOC on students' learning mode and learning commitment, as well as how to evaluate students' learning commitment.

Theoretical Foundations of Student Learning Engagement

Involvement Theory (IT) of learning was proposed by Astin (1984) and conceptualized through the I-E-O (Engagement-Environment-Output) model, and in recent years this theory has been widely applied and extended in different educational contexts. in Astin's study, learning activity is defined as the time, mental

and Emotional Engagement that a student puts into a learning activity (Astin, 1984). In recent years, the multidimensionality of learning activities and their manifestations in different educational contexts have been explored in depth.

In the study of SPOC blended teaching model, Wu et al. (2020) pointed out that learning engagement not only includes behavioral level engagement, but also covers two important dimensions of cognition and emotion. The study found that blended teaching in the SPOC model significantly enhanced students' independent learning ability, especially in terms of emotional engagement, and that students' emotional state and motivation had a significant impact on learning outcomes. In addition, the study emphasized that students' self-directed learning ability and emotional engagement change dynamically over time in the SPOC environment, and this change directly affects their learning outcomes. Therefore, Wu et al. (2020) suggested that teachers should pay more attention to students' emotional experience and cognitive development in SPOC blended instruction to promote their learning engagement.

In the research of SPOC (Small Private Online Course) blended education model, scholars generally focus on its impact on students' learning engagement. Hu Pingxia et al. (2024) explored how to improve students' learning engagement through personalized learning theory by studying the learner portrait under the MOOC and SPOC blended education model. Based on multiple intelligence theory and metacognition theory, the study used K-means cluster analysis method to classify learners into three categories: potential, aggressive, and autonomous, and pointed out that this data-driven personalized learning support can significantly improve students' learning engagement and learning effectiveness.

In addition, Wang et al.'s (2024) study of SPOC forum Interactional behavior patterns showed that students' forum Interactional behaviors in a blended classroom are closely related to learning effectiveness. It was found that differences in frequency of Interactional and expression of emotion among different types of learners (e.g., active learners, followers, and silent learners) had a significant impact on learning outcomes. There was a significant correlation between the frequency of

emotional Interactional and learning outcomes, while the correlation between the frequency of Interactional alone and learning outcomes was weak. This suggests that emotional support and personalized feedback are key factors in enhancing students' engagement in learning in SPOC blended instruction. Another study explored the specific application of the SPOC-based blended teaching model using the Data Structures course as an example. The study points out that this model effectively improves students' learning efficiency and active learning ability through the organic combination of before, during and after-class, and also enhances the Interactional between teachers and students.

These studies suggest that the SPOC blended education model can effectively enhance students' learning engagement and learning effectiveness through personalized learning support, emotional Interactional, and a combination of online and offline instructional design. Future research can further explore how to optimize these strategies to better suit the needs of different disciplines and learner groups.

Zhang et al.'s (2020) study further supports the continuity and variability of learning engagement. By comparing students in an online course with students in a traditional course, this study found that students' psychological engagement, e.g., attention to task, showed significant differences between the two environments, despite the different format of the learning activities. The study noted significant individual differences in student engagement in the same course, and this difference emphasizes the importance of the need to consider individual differences when assessing engagement in learning.

Student Engagement Theory (Engagement Theory) was proposed by Kearsley, an American distance educator, which emphasizes that individuals participate meaningfully in learning activities through realistic tasks and teamwork. In recent years, Engagement Theory has been widely used in blended learning environments. Student engagement theory pays special attention to the individual's role in a team and requires learners to be deeply involved in the learning process through creative, collaborative, and hands-on learning activities (Kearsley & Shneiderman, 1998).

In recent years, with the widespread use of SPOC (Small Private Online Course) and online learning environments, researchers have explored student engagement and its influencing factors in depth. The study by Zhou et al. (2020) pointed out that team task-based learning activities significantly increased students' motivation. By working in teams to complete authentic projects, students not only improved their academic performance, but also enhanced their sense of responsibility and self-efficacy. This learning model stimulated students' learning interest and intrinsic motivation by combining learning tasks with authentic contexts, thus facilitating the occurrence of deep learning.

Luo and Li's (2021) study indicated that project-based learning activities significantly increased students' motivation to work in teams in a blended learning environment. The study emphasized that the three core elements of Learning Engagement Theory (LET) - “Interacting”, “Creating”, and “Contributing” - can significantly increase students' motivation to work together in a blended learning environment. Creating,” and ‘Contributing’-are well represented in these course designs. By working together on complex learning tasks, students not only enhance their understanding, but also increase the depth and breadth of their learning.

Guo et al. (2022) argue that creative learning activities are critical to promoting student engagement in a blended learning model. The study showed that when students are able to apply their learning to real-world projects and produce meaningful outcomes, their engagement in learning increases significantly. This is closely related to the “creating” and “contributing” elements of Kearsley's Engagement Theory, where students are able to work together to produce meaningful outcomes through Project-Based Learning (PBL). Through Project-Based Learning (PBL), students are able to work together to accomplish complex tasks, thereby enhancing their understanding of what they have learned. This mode of learning not only improves students' academic performance, but also stimulates their interest and intrinsic motivation and enhances their sense of responsibility and self-efficacy.

Overall, the theory of student engagement provides theoretical support for learning in SPOC environments, especially in the design of teamwork, creative learning, and contributory tasks. By combining teamwork and project-based learning activities, students are able to take a more active role in the learning process and enhance learning outcomes through Interactional with real-world problems.

The theory of educational evaluation proposed by R.W. Tyler in 1930 emphasized the process of the degree of achievement of educational goals, and tested the effectiveness of educational planning and implementation by specifying and measuring students' behavioral goals. In recent years, Tyler's evaluation theory has been widely used in the field of educational evaluation, especially in measuring the effectiveness of student learning, and its behavioral goal model remains an important theoretical basis for educational evaluation.

Chen and Zhang's (2020) study showed that by transforming educational goals into specific behavioral objectives, teachers can more systematically design lessons, organize teaching activities, and monitor students' learning progress through continuous assessment. This approach not only improves the scientificity and accuracy of assessment, but also provides teachers with a basis for timely adjustment of teaching strategies. By recording students' learning behaviors, such as online learning time, completion of assignments, and participation in discussions, educators can gain a more comprehensive understanding of students' learning status and provide personalized learning support accordingly. This approach combines the advantages of online independent learning and offline Interactional teaching, and can better meet the diverse learning needs of students.

Wang and Li's (2022) study found that the behavioral goal model was effective in linking students' learning Engagement behaviors to actual learning outputs. This assessment model not only assesses learning outcomes through both quantitative and qualitative means, but also improves the accuracy of the assessment through the intrinsic comparison of outcomes and objectives. In SPOC environments, student engagement and learning outcomes can be effectively assessed through the behavioral goal model.

Zhang et al.'s (2021) study points out that in SPOC courses, students' learning behaviors can be distilled into different tasks and objectives. By observing and measuring these specific behaviors, educators are able to more accurately assess student learning processes and outcomes. This type of assessment includes not only quantitative measurements but also covers qualitative analysis, thus providing educators with a comprehensive assessment structure. Through this structure, educators can better understand students' learning engagement and its relationship with learning outcomes, and thus optimize instructional design and learning support. Through clear behavioral goals and result-oriented assessment, educators can better monitor students' learning progress and adjust teaching strategies based on the assessment results. This approach is suitable for SPOC courses because it can effectively integrate the advantages of online self-directed learning and offline Interactional teaching.

Overall, Taylor's educational evaluation theory provides a solid theoretical foundation for constructing an evaluation model of college students' SPOC learning engagement. Its behavioral goal model enhances the precision and utility of educational evaluation by quantifying students' learning behaviors and learning outcomes, and transforming the complex learning process into observable and measurable specific goals. This evaluation model has important guiding significance in constructing the SPOC learning Engagement evaluation model oriented to learning output results.

Dimensions of Student Learning Engagement

Learning engagement is widely recognized as a multidimensional construct whose research perspectives have expanded and deepened over time. Early on, Taylor (1930) first introduced the concept of engagement in the time-on-task dimension, viewing learning engagement as the amount of time and effort students invest in a learning task. However, this single-dimension structure could not fully reflect students' learning behaviors. Subsequently, Finn (1989) proposed that learning engagement consists of two dimensions: behavioral engagement and emotional

engagement. Behavioral engagement refers to the tangible behaviors that students exhibit in classroom activities, such as actively participating in class discussions and completing assignments on time, etc. Emotional engagement, on the other hand, reflects students' sense of belonging to and identification with the learning environment, such as students' interest in the classroom and their closeness to the teacher. This viewpoint laid the foundation for subsequent studies and has gradually been widely accepted. In recent years, researchers have further expanded the dimensions of learning engagement. fredricks et al. (2004) added the cognitive engagement dimension to Finn's, and classified learning engagement into three dimensions: behavioral engagement, emotional engagement, and cognitive engagement. Cognitive engagement mainly involves students' understanding, application and reflection of knowledge during the learning process, such as the use of learning strategies and in-depth thinking about complex concepts. With the depth of research, the dimensional division of learning engagement has become more diverse. Some researchers have proposed a four-dimensional model, including behavioral engagement, emotional engagement, cognitive engagement, and social engagement. Reeve (2012) proposed the concept of agentic engagement, which emphasizes the extent to which students actively participate in the learning process and enrich the learning experience.

Chen et al.'s (2023) study pointed out that college students' learning engagement in a smart classroom environment can be divided into four sub-dimensions: behavioral engagement, cognitive engagement, emotional engagement, and Interactional engagement. Behavioral engagement is reflected in students' active participation in classroom discussions and completing tasks; cognitive engagement involves students' understanding and application of knowledge; emotional engagement reflects students' emotional identification with the learning environment; and Interactional engagement focuses on students' Interactionals with teachers and peers. The study also found that self-efficacy, motivation, perceived ease of use, and teacher support had a significant positive effect on learning engagement.

Wang and Li (2022) divided learning engagement into three dimensions: behavioral engagement, cognitive engagement, and emotional engagement based on Fredricks et al.'s theory. Behavioral engagement includes students' actual actions in mentoring, such as communicating about preparation and participating in discussions; cognitive engagement involves students' knowledge and understanding of mentoring; and emotional engagement reflects students' attitudes and emotional commitment to mentoring. The study found through multiple linear regression analysis that students' learning experience, mentoring process and teacher-student Interactional context were the key factors affecting learning engagement.

Zhang et al. (2021) proposed a three-dimensional structural model incorporating behavioral, emotional, and Cognitive Engagements, emphasizing the importance of Cognitive Engagements in the development of higher-order thinking. The model not only considers students' external behaviors, but also includes their emotional experiences and cognitive processes, constructing a more comprehensive learning assessment framework is widely used to explore complex learning environments, which involves students' comprehension, application, and reflection on knowledge. For example, in online learning environments, cognitive engagement involves not only deep reflection on learning content, but also the ability to use learning strategies and solve complex problems. The model also emphasizes the importance of emotional engagement, i.e., students' emotional response to the learning environment and their sense of belonging, which has a significant impact on students' motivation and persistence.

Schaufeli et al. (2020) constructed a model of learning engagement in terms of the dimensions of energy, dedication, and focus, emphasizing the energy, focus, and perseverance on task exhibited by students during the learning process. The model takes into account students' external behaviors and also includes their emotional experiences and cognitive processes, constructing a more comprehensive framework for assessing learning. The paper argues that the three core dimensions of learning engagement are vigor, dedication, and concentration, which play a key role in students' learning process. Vigor reflects students' energy level and motivation in

the learning process; dedication reflects students' commitment and enthusiasm for the learning task; and concentration emphasizes students' ability to maintain attention during the learning process. This multidimensional model of learning engagement provides educators with a more comprehensive perspective for designing and evaluating instructional activities.

Reeve and Tseng (2022) introduced a new concept of “agentic engagement” that emphasizes the need for students not only to be actively involved in the learning process, but also to contribute constructively to the content and process. This active participation is not only limited to behavioral and emotional dimensions, but also includes how students can positively influence the teaching and learning activities by expressing their interests and providing opinions and suggestions. Agentic engagement is a type of active, purposeful, and reciprocal participation that students demonstrate in the learning process. It enables students to influence the way teachers teach by expressing their interests and preferences, thus creating a more supportive and personalized learning environment. Agentic engagement has also been linked to students' motivational satisfaction and effective learning functions. Students who were more agentically engaged showed greater increases in course-related interest, autonomy need fulfillment, and self-efficacy. This type of engagement not only promotes students' motivation, but also enhances their academic achievement through active exploration and problem solving.

Yin Rui et al. (2021) proposed a learning engagement model based on four dimensions: behavioral, emotional, cognitive and social Interactional from the perspective of online learning. The model emphasizes that learning engagement not only includes the traditional behavioral and emotional dimensions, but also covers cognitive processes and social Interactionals, so as to reflect more comprehensively the students' learning status in the virtual learning environment. Social Interactional dimensions in online learning environments are equally important and can significantly affect students' learning outcomes and learning experiences. By analyzing student behavioral data in online learning platforms, it was found that social

Interactional not only enhances students' emotional engagement, but also promotes cognitive engagement, which in turn enhances overall learning outcomes.

Yin Rui et al. (2021) proposed a learning engagement model based on four dimensions: behavioral, affective, cognitive and interactional engagement from the perspective of online learning. Chen et al. (2023) also proposed a four-dimensional structure of student engagement in smart classroom environments, which includes behavioral, cognitive, emotional, and interactional engagement. This four-dimensional framework is consistent with the conceptualization adopted in the present study, where interactional engagement is regarded as an essential component of student learning engagement in SPOC-based blended teaching.

In summary, research on learning engagement has gradually evolved from a single dimension in the early days to a multidimensional structure that encompasses behavioral, emotional, cognitive, and interactional dimensions. This multidimensional perspective provides educators with a more comprehensive framework for understanding and assessing students' engagement in learning and its impact on learning outcomes

Practical Studies on Student Learning Engagement

In recent years, with the popularization of online learning, learning engagement, as an important indicator of learning quality, has gradually become the focus of research in the field of education. By assessing learning engagement, educators are able to better understand student engagement in the learning process and optimize online learning design. Researchers have conducted a lot of studies on the methods, processes and tools for assessing learning engagement, and are committed to constructing an effective online learning assessment model. With the rapid development of “Internet+Education”, SPOC (Small Private Online Course) blended education model has become an important direction of education reform because it combines the flexibility of online independent learning and the depth of offline Interactional teaching. Research has shown that SPOC blended education model can significantly improve students' learning participation and learning effect.

Hu Pingxia et al. (2024) explored the application of blended teaching mode in vocational education based on the “MOOC+SPOC” platform. The study points out that learners are classified into potential, aggressive and autonomous through K-means clustering analysis, which provides a theoretical basis for personalized learning. The study also emphasized that “data-driven” instructional design can better meet the learning needs of different students, thus enhancing learning engagement.

Luo Guie and Liu Xiaru (2020) studied the blended teaching mode based on the MOOC+SPOC platform, taking the analog electronics technology course as an example. The study pointed out that this mode practiced the teaching concept of “student-centered” by optimizing the course design, teaching methods and assessment methods, and significantly improved students' independent learning ability and collaborative learning ability.

Tan Suyan's (2024) study pointed out that the SPOC blended teaching model can effectively enhance students' learning engagement by improving course design and stimulating students' motivation. The study also found that teachers need to update teaching resources and optimize assessment methods in course design to promote students' transformation from passive to active learning.

Lin Xiaofan et al. (2015) explored the SPOC-based model for cultivating innovative ability, emphasizing that the SPOC model can enhance students' interactivity and participation through the combination of online and offline, thus improving learning effects. The study points out that the SPOC model not only takes advantage of MOOC (Massive Open Online Course), but also enhances the Interactional and personalized instruction between teachers and students through the design of small-scale and private courses.

Shuang Li et al. (2019) constructed a model for assessing distance learning Engagements from behavioral variables of a learning management system. The model not only contains total learning Engagements, but also distinguishes three types of sub-Engagements: cognitive, emotional, and behavioral. By analyzing data on student behavior in distance learning, it was found that cognitive and emotional

Engagements are particularly closely related to academic performance. Cognitive Engagement involves students' understanding and application of knowledge, while emotional Engagement reflects students' emotional responses to the learning environment and their sense of belonging. These two types of Engagement play a key role in students' learning process and significantly affect their learning outcomes. The importance of behavioral engagement s, i.e., students' specific behavioral manifestations in the learning management system, such as frequency of logging in, assignment submission, etc., was also emphasized. These behavioral data provide educators with a more comprehensive perspective to assess students' learning engagement and learning outcomes.

In summary, most studies in recent years have focused on the use of automated assessment tools to objectively assess students' engagement in learning, but relatively few studies have considered subjective initiative. Most studies have borrowed and adapted well-established scales, while fewer tools have been developed independently. However, assessment of learning engagement in online learning environments still has great potential for development, especially in combining automated and subjective assessment.

Evaluation Tools for Student Learning Engagement

With the wide application of online learning and blended teaching modes, the development of effective assessment tools for student learning engagement has become an important direction in educational research. Studies have shown that a multidimensional assessment model can be constructed through the analysis of behavioral data in a learning management system (LMS), thus reflecting students' learning engagement and learning effects more comprehensively.

Jie Fan and Yuexiang Yang (2021) designed and implemented a statistical system for analyzing students' learning behaviors on a distance learning platform. The system provides an effective means to assess students' learning effectiveness and teachers' teaching quality in a distance learning environment by analyzing students' behavioral data in a learning management system. The study points out

that by counting students' learning behaviors, such as login frequency, homework submission, and forum Interactional, students' learning engagement can be effectively assessed.

Zongyang et al. (2024) constructed a model for analyzing distance learners' academic mood based on online learning behavior data and applied it to a case course on the Moodle platform. It was found that learners' academic mood was significantly and positively correlated with their assignment grades, indicating that academic mood has a significant impact on learning outcomes. In addition, the teacher's emotional disposition in the forum positively affects learners' academic mood.

S. Jiang et al. (2024) used logistic regression models to predict the probability of a student's eventual passing of a quiz based on the learner's one-week record of academic behavior. The study demonstrated that learning behavior data can effectively predict students' learning outcomes, providing a new perspective on the assessment of learning engagement.

Hongfei Yan et al. (2022) investigated online data analysis and mining for the Canvas learning management system. Through regression analysis, the study found that students' daily performance, course Interactionals, social relationships, and self-assessment were the key factors affecting academic performance. These findings provide data support for optimizing online instructional design and assessing student learning engagement.

Evans and Zhu's (2023) study developed an Assessment Engagement Scale (AES) to assess the quality of student engagement in higher education. The scale is based on best practice in assessment and feedback and assesses student engagement by analyzing students' roles in the assessment context and their confidence in the assessment requirements, as well as their ability to achieve engagement opportunities. The study established the structural, criterion and convergent validity of the scale through exploratory factor analysis and validation factor analysis.

Zheng Qinhua et al. (2016) investigated the modeling and application of online learning assessment based on learning analytics and proposed a reference model for comprehensive learner evaluation. The model provides a multidimensional framework for the assessment of online learning by integrating behavioral data and learning outcomes in a learning management system. The study points out that this model can reflect student learning more comprehensively, thus providing data support for teaching improvement.

Ewell et al., (2020) developed the NSSE scale in 1999 to assess college students' engagement in educational activities. The NSSE focuses not only on individual student engagement in learning, but also on resource Engagements at the school level. In recent years, the scale has been widely used to assess the quality of higher education and student learning outcomes, however, the NSSE is more suitable for traditional teaching and learning scenarios, and its structure and content are difficult to be directly applied to the online-offline blended learning model of SPOC.

In recent years, some studies have tried to apply the theoretical frameworks of some classical scales to the blended learning model. For example, NSSE-based learning engagement scale and SEDE scale have been used to analyze the learning engagement of college students in blended learning mode. It is found that although some classical scales have been widely used in distance education, their direct applicability in SPOC (Small Private Online Course) blended learning mode is limited. SPOC mode combines online independent learning and offline Interactional teaching, which has the characteristics of blended learning and requires more refined assessment tools. Unlike pure distance education, the learning behavior data (e.g., online learning time, assignment submission, etc.) in the SPOC model provide new perspectives for assessing student engagement. Therefore, future research can further explore how to combine behavioral data analysis with learning management systems (LMS) to optimize and combine traditional scales in the SPOC blended learning model.

Learning Engagement and Learning Effectiveness

In recent years, with the rapid development of educational technology, the SPOC (Small Private Online Course) blended education model has become an important means of enhancing students' learning engagement and learning outcomes because it combines the flexibility of online independent learning with the depth of offline Interactional teaching. The SPOC model improves student learning by optimizing instructional design and learning activities to enhance students' learning participation and learning outcomes through optimizing teaching design and learning activities.

Li Shuang et al. (2019) explored the predictive effects of cognitive, emotional, and behavioral dimensions on learning outcomes by constructing a Learning Management System (LMS)-based assessment model for assessing distance students' learning engagement. The study pointed out that learning engagement is an important factor affecting students' learning achievement and persistence. Automated assessment of distance learners' learning engagement through data recorded by learning management systems can not only optimize the distance learning process, but also provide intelligent learning support services for students.

Zhou Qin et al. (2025) proposed a “blended teaching model based on SPOC, flipped classroom and scenario simulation” and applied it to the teaching practice of the integration course of “locomotor system” for medical students. The study found that this blended teaching model can significantly improve students' participation and interest in learning. Through the combination of online independent learning and offline Interactional teaching, students' performance in class was more active, and their practical ability and innovation ability were also significantly improved.

Hu, Pingxia et al.'s (2024) argued that SPOC blended teaching model can enhance students' learning engagement through personalized learning support and diverse learning activities. By analyzing data from the learning management system (LMS), the study found that students were more engaged in video learning, thematic discussions, and classroom Interactionals, and that these activities provided space for students to think and communicate in depth.

Xixi Lei (2024) studied the impact of SPOC blended teaching mode on students' learning outcomes by taking the C Programming course of Baise College as an example. It was found that through the combination of online independent learning and offline Interactional teaching, students showed significant improvement in knowledge acquisition, application ability and innovative thinking. Specifically, students' task completion rate and classroom Interactional frequency in the course increased significantly, indicating that the blended teaching model can effectively promote students' learning outcomes.

Min Qing (2024) applied the “MOOC + SPOC” blended teaching mode in the course of Basic Principles of Marxism, and found that the blended teaching mode significantly improved students' final grades and learning satisfaction by comparing with the traditional offline teaching mode. The results of this study show that the blended teaching mode can better meet the diverse learning needs of students and improve their learning effect.

Tan Suyan (2024) constructs a SPOC-based convergent OMO teaching model and discusses how to optimize the blended teaching model through practices such as educational information infrastructure, SPOC course resources, teacher education and training, course assessment system and online-offline integration. The study points out that through the combination of system grading, students' mutual assessment and teachers' grading, students' learning can be reflected more objectively, thus improving the learning effect.

Pan and Li (2020) analyzed student engagement in a MOOC (Massive Open Online Courses) learning context and found that learning engagement had a significant positive effect on learning outcome attainment and mediated the relationship between the attributes of the MOOC and learning outcome attainment. Although the study showed that overall engagement was significantly related to learning outcome attainment, the study did not delve into the micro relationships between specific dimensions, such as cognitive, behavioral, and emotional engagement, and learning outcome attainment.

In summary, although a large number of studies have been conducted to analyze the relationship between learning engagement and the achievement of learning outcomes, most of them have focused mainly on specific teaching and learning environments. The complexity of the online-offline blended teaching and learning environments under the SPOC model can significantly improve student learning engagement and learning outcomes by optimizing instructional design and learning activities. However, students' learning engagement and its relationship with learning outcomes have not been fully revealed. Therefore, in order to ensure the broad applicability of the findings, future research on the SPOC blended education model can further explore and incorporate AI and big data technologies and apply them to more disciplines and teaching modes to optimize the SPOC blended education model to better meet the learning needs of different students.

Student Learning Engagement in SPOC-Based Blended Teaching

With the rise of online-offline blended teaching mode, SPOC (Small Private Online Course), as a new teaching mode combining MOOC and traditional classroom, has gained more and more attention in higher education. The SPOC mode combines the flexibility of online learning and the interactivity of classroom teaching, providing students with a rich learning experience. Under this model, researchers have gradually focused on how to assess college students' learning engagement and explored its relationship with the achievement of learning outcomes.

Liang Yunzhen et al.'s (2020) study pointed out that SPOC is a blended teaching model that combines MOOC with traditional classroom. She assessed students' cognitive and emotional engagement through a quasi-experimental research method using a scale and found that online mutual assessment played a significant role in improving students' cognitive engagement. Although the results of the study showed a positive effect, the results need to be further tested as the assessment tool has not been fully empirically validated.

Zhou Qin et al. (2025) proposed a “blended teaching model based on SPOC, flipped classroom and scenario simulation” and applied it to the teaching practice of

the integration course of “locomotor system” for medical students. The study found that this blended teaching model can significantly improve students' participation and interest in learning. Through the combination of online independent learning and offline Interactional teaching, students' performance in class was more active, and their practical ability and innovation ability were also significantly improved.

The study by Suyan Tan (2024) explored how to optimize the blended teaching model through practices such as educational information infrastructure, SPOC course resources, teacher education and training, course assessment system, and online-offline integration by constructing a convergent OMO (Online Merge Offline) teaching model based on SPOC. The study points out that the combination of systematic grading, students' mutual assessment and teachers' grading can reflect students' learning more objectively, thus improving the learning effect.

Pingxia Hu et al. (2024) concluded that the SPOC blended teaching model can enhance students' learning engagement through personalized learning support and diverse learning activities. By analyzing data from the learning management system (LMS), the study found that students were more engaged in video learning, thematic discussions, and classroom Interactionals, and that these activities provided space for in-depth thinking and communication.

Wang et al. (2024) found that there is no significant correlation between the frequency of Interactionals of different types of learners and their learning effectiveness, while there is a significant correlation between the frequency of emotional Interactionals and learning effectiveness by mining the Interactional behavior patterns of SPOC forums. This suggests that emotional support and personalized feedback are key factors in enhancing students' learning engagement in SPOC blended learning.

In summary, the SPOC blended education model can significantly improve students' learning engagement and learning outcomes by optimizing instructional design and learning activities. Future research can further explore how to combine artificial intelligence and big data technologies to optimize the SPOC blended education model to better meet the learning needs of different students. Through

the application of these technologies, the SPOC model will be able to better adapt to the needs of education in the new era and provide students with a more personalized and efficient learning experience.

Related Research

Challenges in Developing Learning Engagement Models for Blended Teaching

Researchers have faced several challenges in developing learning engagement models for blended teaching models based on SPOC platforms. First, the complexity and diversity of students' learning behaviors in different learning environments make it difficult to construct learning engagement models. Li et al. (2020) pointed out that the heterogeneity of students' learning in blended teaching environments leads to significant differences in the manner and degree of learning engagement, which affects the reliability and validity of unified evaluation models. Therefore, developing engagement models that can take into account individual student differences is an important challenge in this field.

In addition, students' self-regulation ability is also one of the important factors affecting the construction of models. Xie and Ke (2021) found that students' self-regulated learning ability directly affects their level of engagement in blended learning, and thus models need to fully take into account individual differences in self-regulation.

In addition, the uniqueness of the SPOC model makes it difficult for existing evaluation tools to adapt to its complex pedagogical characteristics. Sun and Rueda (2019) noted that learning engagement evaluation methods for distance education are not fully applicable to the SPOC model, as its blended instruction involves both online learning and classroom Interactionals. These challenges suggest the need to develop more flexible and highly applicable learning engagement assessment tools to address the specificities of blended learning contexts.

Factors Influencing Learning Engagement in Blended Teaching Models:

Learning engagement is influenced by a variety of factors, especially in SPOC blended teaching models. Zhao et al. (2021) found in their study that the instructor's

teaching style and the students' ability to self-regulate their learning were important factors influencing learning engagement. They pointed out that the teacher's role in blended teaching is not only as a transmitter of knowledge, but also as a guide and motivator of learning in order to increase students' emotional engagement.

In addition, the learning environment is also one of the important factors affecting learning engagement. Chen and Xu (2022) found that the design of the learning platform was significantly related to students' learning engagement, and that a good user experience could enhance students' motivation and engagement in learning. The availability and ease of use of learning resources were also identified as one of the key factors influencing learning engagement. The study of these factors suggests that multiple dimensions such as teaching strategies, learning tools, and environment design need to be considered when constructing a model of SPOC learning engagement in order to enhance the level of student engagement.

In addition, students' social support and peer Interactionals are also important factors affecting learning engagement. Liu et al. (2022) noted that positive Interactionals and support among peers can significantly enhance students' emotional engagement and behavioral engagement. This social support is particularly important in a blended learning model because it can compensate for the isolation that can occur in online learning.

Methodologies for Assessing Learning Engagement in Blended Teaching:

There are various methods for assessing learning engagement in blended teaching in the SPOC model. In recent years, researchers have used a variety of quantitative and qualitative methods to assess students' learning engagement. Zhang et al. (2021) used Structural Equation Modeling (SEM) to analyze the multidimensional structure of learning engagement in a SPOC environment and assessed the impact of each dimension on learning outcomes. Their study proved that SEM has good applicability and explanatory power in analyzing learning engagement.

Meanwhile, the collection and analysis of behavioral data have gradually become an important method for learning engagement assessment. Macfadyen et al.

(2018) provided a new way to quantify learning engagement by tracking students' online behaviors using LMS data and predicting students' learning effects through regression analysis. The diversity of these research methods suggests that a combination of approaches should be used when assessing learning engagement in order to gain a comprehensive understanding of student learning in blended instruction.

In recent years, the application of learning analytics techniques has also emerged. Khalil and Ebner (2021) found that students' learning paths and behavioral patterns were closely related to their learning engagement by analyzing learning behavior data. Learning analytics provide a more dynamic and real-time means of assessing student engagement in blended learning environments.

Future Directions in Learning Engagement Research for Blended Teaching Models:

In the future, research on learning engagement in SPOC (Small Private Online Course) blended learning models should focus on several key areas. First, there is a need to further develop and validate learning engagement assessment tools that are applicable to blended learning environments. These tools should not only be culturally adaptive but also sensitive to different learning environments (Guo & Wang, 2022). In addition, artificial intelligence and big data analytics offer new possibilities for assessing learning engagement. Zheng et al. (2022) suggested that analyzing students' learning behavior data through machine learning algorithms can more accurately predict students' learning engagement and learning outcomes. The application of these techniques will greatly improve the efficiency and accuracy of learning engagement assessment and provide strong support for personalized teaching. Meanwhile, future research should also focus on the exploration of personalized learning paths. SPOC blended teaching models offer the possibility of personalized learning, while learning engagement models can support personalized learning through a better understanding of students' learning behaviors and engagement levels (Huang & Chen, 2023). By integrating personalized learning

analytics, future research can delve deeper into how to use data-driven approaches to maximize learning outcomes by tailoring optimal learning paths for each student.

In addition, research on collaborative learning and social Interactionals should be further strengthened. The combination of online and offline in the SPOC model provides rich opportunities for social Interactionals, and future research could more systematically analyze how these Interactionals affect learning engagement and how they can be optimized to increase student motivation and achievement (Liu et al., 2023). These explorations are important for improving the overall quality of blended learning. Finally, future research should focus on the integration and innovative use of technology in blended learning models. Emerging technologies such as intelligent recommender systems and personalized learning assistants have shown great potential in improving learning engagement (Wang & Li, 2023). By combining these technologies, researchers can develop more flexible and smarter learning environments that will enhance students' learning experience and engagement in blended learning.

In conclusion, the SPOC blended learning model shows great potential to enhance the student learning experience and promote personalized learning. However, researchers have faced many challenges in developing learning engagement models, including the complexity and diversity of student learning behaviors and the impact of cultural context on learning engagement. Future research should further develop assessment tools applicable to different learning environments, focus on the causal relationship between learning engagement and learning outcomes, and make full use of technologies such as artificial intelligence and big data to drive innovation in learning engagement assessment. Meanwhile, the exploration of personalized learning paths and the enhancement of cooperative learning are also important directions for future research. Through these efforts, the SPOC blended teaching model is expected to play a more important role in higher education and provide students with a more efficient and personalized learning experience.

Chapter 3
Research Methodology

The main objective of this study is to develop a learning engagement model for blended teaching of college students' marketing courses based on the SPOC digital platform, and to evaluate the effectiveness of the model. The overall research process is divided into three phases, which are divided as follows:

Phase 1: Answer research objective 1, what is the current status of the blended teaching model of college students in marketing courses, and extract the dimensions and elements of the evaluation model based on the current situation.

Phase 2: Answer research objective 2, develop a learning engagement model based on the blended teaching of college students' marketing courses on the SPOC digital platform, deeply explore the characteristics of students' engagement in the context of SPOC blended teaching, and complete the model construction.

Phase 3: Answer Research Objective 3 to evaluate the effectiveness of the learning engagement model developed based on the blended teaching of the SPOC digital platform for college students' marketing courses.

Phase 1 was conducted to answer research objective 1: to survey the current status of student learning engagement in SPOC-based blended teaching and to identify the dimensions and measurement items of the learning engagement evaluation model. The research instruments used in this phase included the student learning engagement questionnaire, the expert consultation form, and the Item-Objective Congruence (IOC) evaluation form. The questionnaire was reviewed by experts and revised according to their suggestions. If the questionnaire was not approved, it was revised and resubmitted for further review until it was approved.

The research steps in this phase are shown in Figure 3.1.

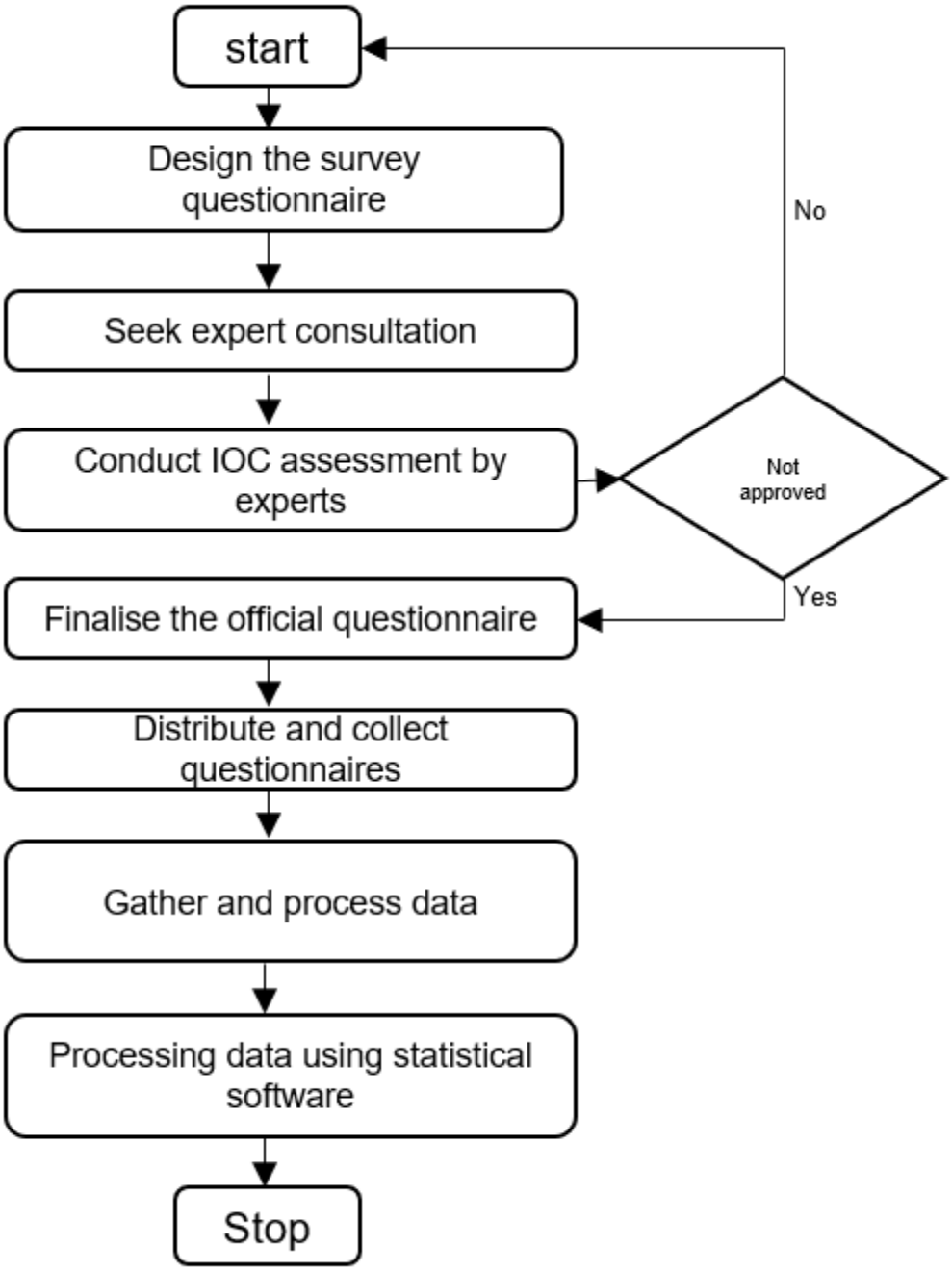

Figure 3.1 Step 1: Survey on the current status of blended learning model in marketing courses for university students

Research steps

In order to achieve the objective of Phase 1, the following research steps were carried out.

First, the researchers designed a survey questionnaire for undergraduate students majoring in marketing and related disciplines in order to assess their learning engagement in SPOC-based blended teaching. After the first draft of the questionnaire had been prepared, it was submitted to five experts and scholars in related fields for consultation. These experts had more than 10 years of teaching and research experience in marketing, business administration, financial management, and other related fields. All of them held master's or doctoral degrees, and most were professors or associate professors.

Second, based on the experts' comments and suggestions, the questionnaire was revised accordingly. The revised questionnaire was then assessed by the same five experts using the Item-Objective Congruence (IOC) method in order to examine its content validity. If the questionnaire was not approved, it was revised again and resubmitted for further review until an acceptable version was obtained. Once the questionnaire was approved, the official questionnaire was finalized.

Third, in order to further improve the quality of the questionnaire, three rounds of pre-surveys were conducted with a total of 71 students. Based on the results of each pre-survey, some items were revised, merged, or deleted to improve clarity and reliability.

Fourth, after the official questionnaire had been finalized, the researchers applied for permission to collect data from six universities in Liaoning Province. After permission had been granted, the questionnaire was distributed to 1,080 students, and 895 valid questionnaires were collected, yielding a valid response rate of 82.59%.

Finally, the collected data were gathered, processed, and analyzed using statistical analysis software and structural equation modeling software. Descriptive statistics, reliability analysis, confirmatory factor analysis, and discriminant validity tests were conducted. Based on the analysis results, a four-dimensional structure of

student learning engagement was identified, including behavioral engagement, cognitive engagement, emotional engagement, and interactional engagement, with a total of 15 measurement items.

Through these steps, the study ensured the scientific rigor and rationality of the questionnaire development process, clarified the current status and dimensions of student learning engagement in SPOC-based blended teaching, and provided a validated instrument for the subsequent model construction and experimental research.

The population / Sample Group

Population

The population of Phase 1 consisted of two groups. The first group included 1,080 undergraduate students majoring in marketing and related disciplines from six universities in Liaoning Province, China. The second group consisted of 35 experts and scholars from the same universities who had more than 10 years of teaching and research experience in marketing, business administration, financial management, and other related fields.

The Sample Group

In Phase 1, the student sample size was n = 1,080. These students were selected from the marketing and related majors of the six universities as the survey sample. After data collection, 895 valid questionnaires were obtained. In addition, 5 experts were selected from the 35 experts and scholars to form the expert consultation panel, and the same 5 experts also served as the IOC verification panel. Three rounds of pre-surveys were conducted with a total of 71 students before the formal survey.

Research Instruments

1. Student learning engagement questionnaire for SPOC-based blended teaching;

2. Expert consultation form for developing and revising the questionnaire instrument;

3. Item-Objective Congruence (IOC) evaluation form for validating the questionnaire instrument, completed by five experts.

Designing Instrument

1. Based on the literature review and existing learning engagement scales, the initial questionnaire instrument for evaluating student learning engagement in SPOC-based blended teaching was developed.

2. The first draft of the questionnaire was designed, consisting of items covering behavioral, cognitive, emotional, and Interactional engagement dimensions.

3. The first draft of the questionnaire was submitted to 5 experts to check the correctness, clarity, and completeness of the items.

4. The validity of the questionnaire was assessed by the same five experts through the Index of Item-Objective Congruence (IOC) with the following criteria:

+1 = Determine that the content is relevant to the topics

0 = Unsure that the content is relevant to the topics

-1 = Content is irrelevant to the topics

Acceptable items must have an IOC value of no less than 0.5. The IOC calculated from the validation measures will be used to determine the relevance of each questionnaire question to the research objectives and ensure the quality of the collected data.

5. Design a Likert 5-point rating scale questionnaire according to the following rating criteria.

Rating criteria

5 means strongly agree

4 means agree

3 means neutral

2 means disagree

1 means strongly disagree

Data Collection

The data collected in Phase 1 were analyzed using descriptive statistics, reliability analysis, validity analysis, exploratory factor analysis, confirmatory factor analysis, and discriminant validity testing. These analyses were used to examine the current status of student learning engagement and to identify the dimensions and indicators of the questionnaire.

Data Analysis

Descriptive statistics, i.e., frequency, mean (M), standard deviation (S.D.), as well as reliability analysis, confirmatory factor analysis (CFA), and discriminant validity tests.

Expected Output Phase1

The current status of SPOC blended teaching and learning engagement among university students, and the validated four-dimensional structure (behavioral, cognitive, emotional, Interactional) with 15 measurement items for learning engagement evaluation.

Phase 2 was conducted to answer research objective 2: To develop a learning engagement model based on the blended teaching of college students' marketing courses on the SPOC digital platform.

The flowchart of the second phase implementation is shown in Figure 3.2

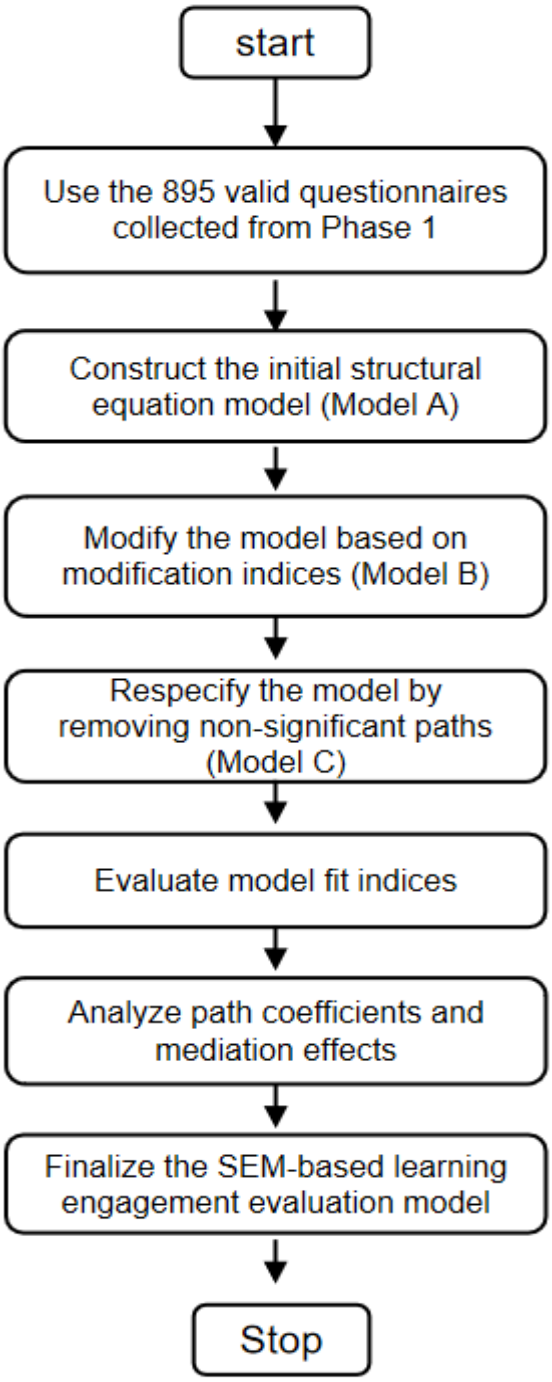

Figure 3.2 Modeling Process of Learning Engagement Evaluation Model for Blended Teaching of Marketing Courses for College Students Based on SPOC Digital Platforms

Research Steps

In the second phase of this study, we used the 895 valid questionnaires collected from Phase 1 to construct a structural equation model for learning engagement assessment.

Using structural equation modeling software, an initial theoretical model (Model A) was first specified based on the four-dimensional structure identified in Phase 1. The model was then modified according to the modification indices, and a path from emotional engagement to behavioral engagement was added, resulting in Model B. Since the direct path from Interactional engagement to behavioral engagement was not significant, it was removed, and Model C was obtained.

The model fit was evaluated using several fit indices, including chi-square/df, CFI, RMSEA, and SRMR. All indices met the acceptable standards, indicating that the final model had a good fit with the data.

We then conducted path analysis and mediation effect estimation. The results showed a chain mediation structure, with emotional engagement influencing behavioral engagement through cognitive engagement, and Interactional engagement serving as an antecedent of both emotional and cognitive engagement.

Through these steps, we developed a finalized SEM-based learning engagement evaluation model for blended teaching of undergraduate marketing courses based on the SPOC platform. This model provides a theoretical foundation and an empirical tool for assessing and improving student learning engagement in subsequent teaching practice.

The population / Sample Group

The population

The population in Phase 2 consisted of 35 experts and scholars from six universities in Liaoning Province who had more than 10 years of teaching and research experience in marketing, business administration, financial management, and other related professional fields, and 1,080 undergraduate students majoring in marketing and related disciplines from six universities in Liaoning Province.

The Sample Group

In phase 2, model development was based on the 895 valid questionnaires collected in the first phase, with a sample size of n=895. In addition, five experts selected from 35 scholars continued to serve on the expert advisory group and the IOC group, resulting in a final expert sample size of n=5.

Research Instruments

1. The validated questionnaire developed in Phase 1 (see Appendix C)
2. Course syllabus and lesson plan
3. Examination papers

Designing Instrument

1.Based on the literature review and the four-dimensional framework identified in Phase 1, the initial structural equation model was developed.

2. The first draft of the SEM model was specified using structural equation modeling software, consisting of four latent variables: behavioral engagement, cognitive engagement, emotional engagement, and Interactional engagement.

3. The initial model (Model A) was submitted to 5 experts for consultation to check the logical consistency and theoretical appropriateness of the path relationships.

4. After collecting and processing the feedback from the experts, the model was revised accordingly.

5. The validity of the model was assessed through model fit indices, including chi-square/df, CFI, RMSEA, and SRMR. Acceptable model fit standards were applied to evaluate the appropriateness of the model.

6. Based on the modification indices and theoretical justification, the model was iteratively refined, resulting in Model B and Model C.

7. A 5-point Likert scale was used in the questionnaire, which had already been developed and validated in Phase 1. The rating criteria are as follows:

5 means strongly agree

4 means agree

3 means neutral

2 means disagree

1 means strongly disagree

Data Collection

The 895 valid questionnaires collected from Phase 1 were used as the data source for Phase 2 analysis.

Data Analysis

Descriptive statistics, confirmatory factor analysis, structural equation modeling, model fit evaluation, path analysis, and mediation effect estimation.

Expected Output Phase2:

Learning Engagement Evaluation Model for Blended Teaching of Marketing Courses for Undergraduates Based on SPOC Digital Platform.

Phase 3 was conducted to answer research objective 3: To evaluate the effectiveness of developing a student learning engagement model for blended teaching based on the SPOC digital platform.

The flowchart of the third phase implementation is shown in Figure 3.3

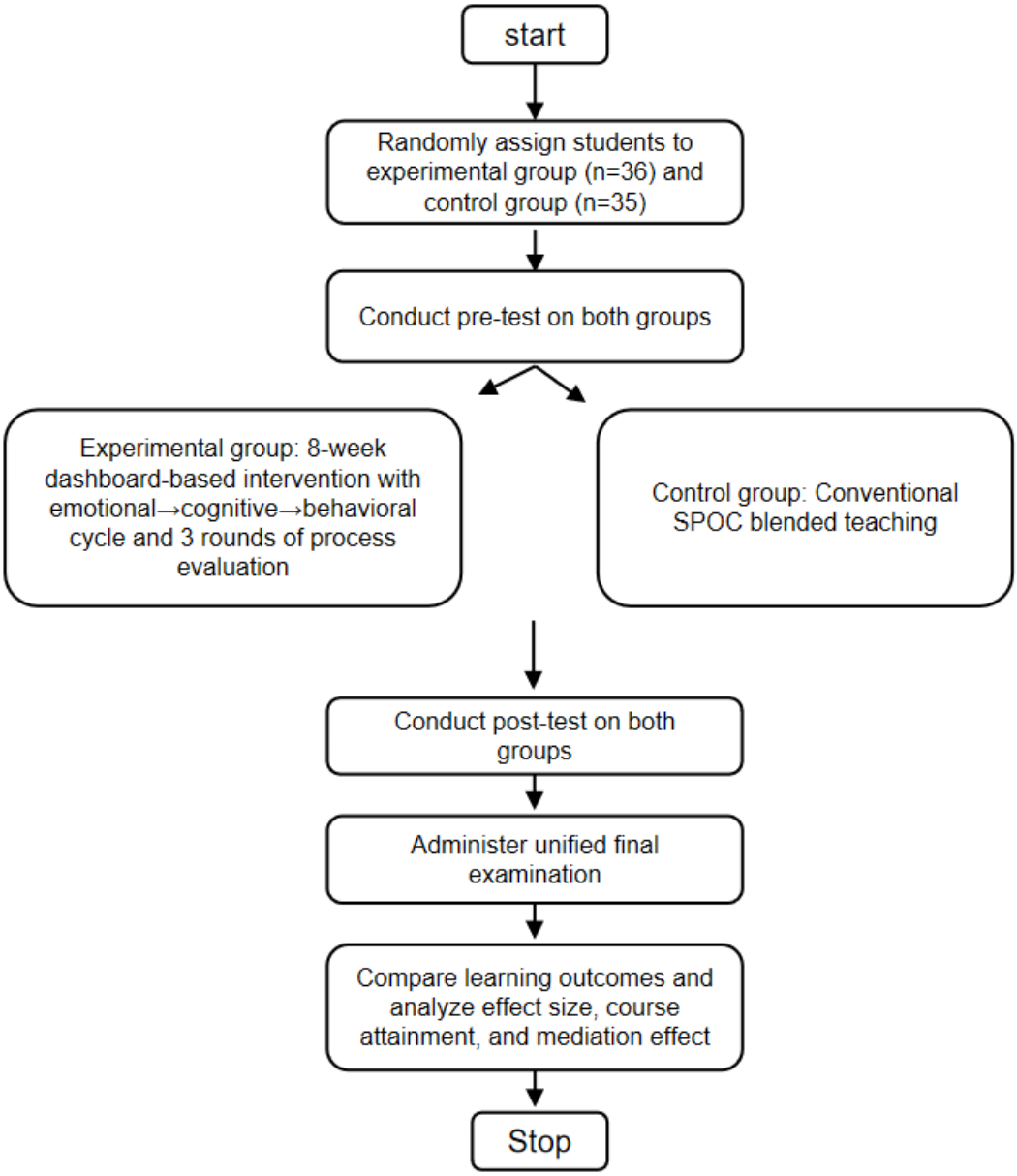

Figure 3.3 Validation Process of Learning Engagement Model (SEM) for Blended Teaching of Marketing Courses for Undergraduates Based on SPOC Digital Platforms.

Research Steps

In phase 3 of this study, we conducted an 8-week randomized controlled trial to evaluate the effectiveness of the developed learning engagement model.

A total of 71 students were randomly selected and divided into two groups: an experimental group of 36 students and a control group of 35 students. The

experimental group adopted a dashboard-based teaching intervention designed around an emotional activation, cognitive deepening, and behavioral externalization cycle, with three rounds of process evaluation and instructional adjustment. The control group followed the conventional SPOC blended teaching procedure without additional intervention.

Both groups completed the validated learning engagement questionnaire as a pre-test before the intervention and as a post-test after the intervention. A unified final examination was also administered at the end of the course to assess students' learning outcomes.

After collecting the data, we conducted independent and paired t-tests, calculated effect size, analyzed course attainment, and estimated mediation effects. The results showed that the experimental group significantly outperformed the control group in both formative and summative assessments, with course attainment levels improving by 18.6% and emotional engagement accounting for 42% of the mediating effect.

Through these steps, we not only evaluated the impact of the learning engagement model on student learning outcomes, but also verified its rationality, scientificity, and applicability in SPOC-based blended teaching. This provides a scientific basis and practical reference for improving student learning engagement and reforming higher education teaching.

The population / Sample Group

The population

The population in Phase 3 consisted of two groups. The first group included undergraduate students majoring in marketing at the Liaoyang Branch of Shenyang University of Technology. The second group consisted of 35 experts and scholars from six universities in Liaoning Province who had more than 10 years of teaching and research experience in marketing, business administration, financial management, and other related professional fields.

The Sample Group

In phase 3, 71 students were selected from the Marketing major at the Liaoyang Branch of Shenyang University of Technology, and the sample size was n = 71. They were randomly divided into two groups: a control group of 35 students (n = 35) and an experimental group of 36 students (n = 36). In addition, 5 experts selected from the 35 experts and scholars had previously served as the expert consultation panel and the IOC verification panel in this study.

Research Instruments

1. The validated questionnaire developed in Phase 1 (see Appendix C)
2. Course syllabus and lesson plan
3. Examination papers

Designing Instrument

Study Engagement Evaluation (SEM) Questionnaire

1. The learning engagement evaluation model for blended teaching based on SPOC digital platform was applied in the marketing course.

2. The validated Learning Engagement Evaluation questionnaire developed in Phase 1 was used as the measurement instrument.

3. The questionnaire had already been reviewed by 5 experts and tested through IOC in Phase 1 to ensure its correctness and validity.

4. A 5-point Likert scale was used in the questionnaire according to the following rating criteria:

Score rating criteria

5 means strongly agree

4 means agree

3 means neutral

2 means disagree

1 means strongly disagree

5. See Appendix C3 for details of the questionnaire.

lesson plan

1. To study the syllabus for blended teaching of Marketing course based on SPOC digital platform.

2. Design two teaching programs, one for the experimental group and the other for the control group. The main contents include course teaching objectives, teaching program, teaching calendar and course assessment program.

3. Submit the teaching plans to 5 assessment experts to check the correctness and completion.

4. Assess the validity of the designed teaching plans by 5 experts through Item-Objective Congruence (IOC) according to the criteria as shown below:

+1 = Sure that the question item is related to the objective

0 = Not sure whether the question item is related to the objective

-1 = Sure that the question item is not related to the objective

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures provides insights into the relevance and coherence of the rubric scoring criteria.

5. the instructional program was piloted separately for the experimental and control groups.

6. The details of the lesson plans for the experimental and control groups are shown in Table 4.47 and Table 4.49.

Exam paper

1. Refer to the standard for proposing examination papers of Shenyang University of Technology.

2. Design a question paper for the Marketing examination for undergraduate students.

3. Submit the first draft of the question paper to 5 experts to check for correctness and completion.

4. Assess the validity of the designed pretest and posttest by 5 experts through Item-Objective Congruence (IOC) according to the criteria as shown below:

1 = Sure that the question item is related to the objective

0 = Not sure whether the question item is related to the objective

-1 = Sure that the question item is not related to the objective

The acceptable items must have the IOC values not less than 0.5. The IOC calculated from the validation measures provides insights into the relevance and coherence of the rubric scoring criteria.

5. The details of the question paper are in Appendix C10.

Data Collection

1. Obtain permission from the school to collect data.

2. Use the Learning Engagement Evaluation (SEM) model to collect student learning data.

Data Analysis

Descriptive statistics, including mean (M) and standard deviation (SD), were used to summarize the data.

Independent samples t-test and paired samples t-test were conducted to compare the differences between and within the experimental group and the control group.

The effect size was measured by Cohen‘s d value. The d value can be expressed by the following formula

$$d = \frac{M_1 - M_2}{SD_{\text{pooled}}}$$

The d values calculated from the above formula were interpreted according to the following criteria:

Table 3.1 Criteria for judging experimental results

Effect size	Effect	Value
d = 0.2	Small	Smaller
d = 0.5	Middle	Medium
d = 0.8	Big	Bigger

Expected Output Phase3

The rationality and scientific validity of a learning engagement model (SEM) for blended teaching of a marketing course for university students based on the SPOC digital platform.

Chapter 4
Results of Analysis

The primary objective of this study is to develop a learning engagement model for blended teaching in college marketing courses based on the SPOC digital platform, and to conduct data validation and refinement of the theoretical model. The research aims are as follows:1) Investigate the current state of student learning engagement patterns in blended teaching based on the SPOC digital platform.2) Develop a model for assessing student learning engagement in blended teaching based on the SPOC digital platform.3) Evaluate the effectiveness of developing a student learning engagement model for blended teaching based on the SPOC digital platform.

This chapter will present and analyze the research findings in detail. The data analysis results can be summarized as follows:

1. Symbol and abbreviations
2. Presentation of Data Analysis
3. Results of data analysis

The details are as follows.

Abbreviations and Analytical Tools

Building upon the theoretical foundations explored in Chapters 1 and 2, this chapter presents a preliminary framework for a learning engagement model in blended teaching of university marketing courses delivered via the SPOC digital platform. The primary data collection tool employed is a survey questionnaire. Statistical analysis software, structural equation modeling software, and spreadsheet software were used to progressively test the measurement model and the structural model within the SEM framework. The analysis primarily focuses on verifying the model's validity and assessing the questionnaire's reliability and validity. Upon meeting reliability and validity standards, the theoretical model undergoes further validation and refinement through structural equation modeling.

Abbreviations Used in This Chapter:

M = Mean

SD = Standard Deviation

α = Cronbach's Alpha (internal consistency coefficient)

CFA = Confirmatory Factor Analysis

CR = Composite Reliability

χ^2 = Chi-square statistic

STD=Standardized factor loading

t-test = Student's t-test (used for comparing means)

ANOVA = Analysis of Variance

n = number of respondents

Quantitative Analytical Tools:

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were computed using statistical analysis software and spreadsheet software to summarize participants' responses.

Confirmatory factor analysis (CFA) was employed to assess the measurement model. Following conventional reference thresholds for Cronbach's α, composite reliability (CR), and average variance extracted (AVE), we evaluated the instrument's reliability, convergent validity, and discriminant validity.

The university students' SPOC learning engagement evaluation model comprises multiple dimensions. Behavioral, cognitive, Interactional, and emotional engagement are all latent variables; they are not directly observable and must be inferred from other indicators, together forming a network of causal relations. Given the model's complex causal structure, structural equation modeling (SEM) was used to analyze the evaluation model.

Structural equation modeling (SEM) is a statistical approach that integrates factor analysis, path analysis, and multiple regression. Compared with traditional factor-analytic techniques, SEM offers characteristics and advantages that align more closely with practical research needs. In this study, structural equation modeling software was used to specify and estimate the SEM in order to analyze the

preliminarily constructed dimensions and indicators of university students' SPOC learning engagement, and subsequently to test and refine the theoretical model. Assessing the degree of correspondence between the dimensions, indicators, and the observed data constitutes the core of SEM analysis. To accurately and comprehensively evaluate model fit, both basic fit indices and overall fit indices were examined, and the full set of fit statistics was considered in combination.

Although the scholarly community broadly agrees on model-fit criteria, minor differences exist across applications. Drawing on widely accepted recommendations and the aims of this study, we compiled the indices and decision rules used herein:

1. The basic adaptation indicators and standards of the model are shown in Table 4.1;

2. The overall model fit index, commonly used adaptation index and fit value are shown in Table 4.2.

Table 4.1 Basic Fit Indices and Standards for Structural Equation Models

Fit Indicator	Fit Standard
Whether there is negative error variance	No negative error variance
Whether all error variances are statistically significant	All error variances should be statistically significant (C.R. ≥ 1.96)
Whether the absolute value of the correlation between the estimated parameter statistics is too close to 1	The absolute value of the correlation coefficient between variables should not be too close to 1
Whether the factor load coefficient value is between 0.5~0.95	The factor load coefficient needs to be between 0.50~0.95
Whether standard errors are excessively large	Standard errors should not be excessively large

Table 4.2 Overall Model Fit Indices and Recommended Thresholds.

Fit index	Fit criterion
Absolute fit indices	
x^2	p-value > 0.05 (non-significant)
GFI	≥0.90
AGFI	≥ 0.90
RMR	≤0.05
SRMR	≤0.05
RMSEA	≤0.05(Good fit) 0.05~0.08 (Acceptable)
value-added fit indicators	
NFI	≥ 0.90
RFI	≥ 0.90
IFI	≥ 0.90
TLI(NNFI)	≥ 0.90
CFI	≥ 0.90
Minimalist fit indicator	
PGFI	≥ 0.50
PNFI	≥ 0.50
NC value (x2/df) value	1~3 (Good Fit) 3~5 (Acceptable) 5 or more (model needs to be corrected)
CAIC	The CAIC value of the theoretical model is less than that of the independent model and less than the CAIC value of the saturated model

Qualitative Analytical Tools:

The primary data collection tool is a survey questionnaire, drawing upon established evaluation instruments from both domestic and international sources. These include Dixson's (2010) Online Student Engagement Scale (OSE), Reeve's (2011) Student Learning Activities Engagement Scale, Sun (2012)'s “Distance Education

Student Engagement Scale," Gunuc (2015)'s "Student Engagement Scale," and domestic instruments such as Zhang Si (2017)'s "Measurement Model of Learner Engagement in Online Learning Spaces," Liu Qingtang (2017)'s "User Online Behavioral Engagement," Cai Yuhao (2017)'s "Informal Online Learning Engagement Questionnaire," among others. This questionnaire was localized based on the learning status and teaching environment characteristics of SPOC classroom students obtained from preliminary interviews, resulting in the "Questionnaire on College Students' SPOC Learning Engagement."

Overview of Data Collection and Analysis

This study collected and analyzed data through a structured design corresponding to three research phases aligned with the study objectives. Each phase primarily employed cluster sampling supplemented by random sampling, utilizing distinct data sources and analytical methods to ensure that both quantitative and qualitative findings possess high representativeness and mutually corroborate each other.

Phase 1: A questionnaire titled "Current Implementation Status of SPOC-Based Blended Online-Offline Teaching Model in College Marketing Courses" was distributed to 1,080 undergraduate students across all four grades in relevant majors at six institutions. This gathered insights into the need for evaluating learning engagement within this teaching model and identified dimensions and elements for the evaluation framework based on current practices. Data was further collected through scoring by 5 assessment experts to validate the selected dimensions and elements.

The Item-Objective Congruence (IOC) index was used to assess the content validity of the questionnaire through expert evaluation. evaluating the validity of the hybrid teaching model survey in university marketing courses. KMO values and confirmatory factor analysis were used to analyze quantitative data from expert interviews, assessing the validity of expert opinions.

Phase 2: Developed a learning engagement model for blended teaching in university marketing courses based on the SPOC digital platform, establishing a structural equation model comprising 4 dimensions and 15 elements.

Phase 3: The 71 students from two classes were divided into an experimental group and a control group. During the implementation of blended learning for the SPOC digital platform marketing course, the experimental group continuously evaluated, provided feedback on, and improved the SPOC teaching model using the Engagement SEM model, while the control group maintained the original model. Differences in exam scores and course learning outcome achievement between the two groups were compared to measure the effectiveness of the Engagement SEM evaluation model.

Both groups were examined separately, comparing differences in exam scores and course learning outcomes achievement, supplemented by feedback surveys and teacher-student interviews. Quantitative methods employed paired t-tests and independent t-tests to assess model validity. Qualitative approaches gathered questionnaire feedback on the Learning Engagement Evaluation (SEM) model application, ensuring evaluation consistency and providing further assurance for quantitative findings.

Through this structured, phased approach to data collection and analysis, this study ensures comprehensive coverage of the three research objectives and maximizes the validity of the analytical findings.

Findings Related to Objective 1 –Descriptive Statistics of the SPOC Teaching Model Implementation Survey

To ensure the survey sample is more representative and fully reflects the overall learning engagement of university students on the SPOC platform, a brief overview of the sample distribution must be provided before analyzing the formal survey responses.

A total of 1,080 undergraduate students from four grade levels in marketing-related majors at six universities, including Shenyang University of Technology and

Shenyang University of Chemical Technology, participated in this research phase. Participants were selected through cluster sampling.

The questionnaire comprises three main sections: First, introductory remarks and instructions, with the instructions primarily describing and defining SPOC. Second, the main questionnaire body, featuring items designed using a 5-point Likert scale, The third part collected demographic information, including the respondent's school, major, gender, class ranking based on final exam scores, grade level, and total number of students in their class.

To avoid unnecessary waste of manpower and resources, three rounds of pre-surveys were conducted prior to formal distribution. The pre-survey questionnaire was refined using data from small-sample pilot tests. Pre-survey participants were selected for their extensive SPOC learning experience, specifically targeting 2022-level students from a university who had participated in SPOC courses.

The first pre-survey questionnaire comprised 40 items and was administered to 71 students. Based on test data and practical considerations, random interviews were conducted with some test participants. The first round of predictions and interviews revealed that certain items were not accurately understood or aligned with the survey objectives. Consequently, the initial questionnaire was revised and items were removed based on the test results.

The second pre-survey questionnaire comprised 28 items. Analysis of the results indicated that the items were clearly worded and generally aligned with the survey objectives. However, participants still reported high inter-item correlation for certain questions. Consequently, highly correlated items were modified, deleted, or merged.

The third-round pre-survey questionnaire comprised 15 items. Results confirmed clear item meaning, alignment with survey objectives, and satisfactory reliability and validity, enabling large-scale distribution.

A total of 71 students participated in the three rounds of pre-surveys. All participants were from the same target population and some students took part in more than one round.

The final formal survey, “Survey on College Students’ SPOC Learning Status and Engagement,” featuring 15 items in its main body, was deployed for extensive data collection (see Appendix C).

Missing Value Treatment

Since the questionnaire included a question about “class ranking based on final grades,” the collected data contained ambiguous textual responses such as “I don't remember” or “I don't know.” These instances were treated as missing data. Therefore, prior to modeling, such textual answers were marked as missing in the Excel spreadsheet. Subsequently, statistical analysis software was used to handle the missing data by imputing missing values with the mean.

Since the “Major” and ‘School’ items in the questionnaire were text-based fill-in-the-blank questions, respondents used inconsistent terminology when entering responses. During statistical analysis, different expressions referring to the same major or school were grouped into one category. For example: * “E-commerce,” “E-commerce,” “Electronic Information and Business,” “E-commerce Major,” and “E-commerce Studies” were all grouped under “E-commerce” major; “Shenyang University of Technology Liaoyang Branch,” “Liaoyang Branch,” and “Shenyang Tech Liaoyang Branch” were grouped under “Shenyang University of Technology Liaoyang Branch.” Detailed statistical results are presented in Table 4.3.

Content validity test of the questionnaire

The questionnaire employed expert interviews to test content validity, ensuring its accurate reflection of the four dimensions: " behavioral engagement," "Interactional engagement" "emotional Engagement," and "Cognitive Engagement."

Expert Composition: Five experts were invited to participate in the review. All five had over 10 years of teaching or research experience in business administration-related fields and held professorships or doctoral degrees, ensuring the professionalism and authority of the review process.

Testing Process and Methods: The Item-Objective Consistency Index (IOC) method was used. Experts were provided with a theoretical model framework and

initial items, and were asked to independently assess the relevance of each item to the pre-defined dimensions:

+1 point: Very suitable

0 point: Uncertain relevance

-1 point: Unsuitable

The IOC value for each item and the questionnaire as a whole was calculated using the following formula:

$$IOC = (N_{+1} - N_{-1}) / N$$

Testing Results and Questionnaire Revision: The first round of review determined the model dimensions and elements: For the four dimensions and 15 elements, the overall IOC value was 0.92, indicating a high degree of consensus among experts regarding the theoretical model structure.

The second round of review determined the specific measurement items: the initial items were reviewed, and the overall IOC was 0.89.

Finalizing the questionnaire: the items were revised based on expert feedback, resulting in a formal questionnaire containing 15 core items. Both rounds of IOC values exceeded the acceptance standard of 0.80, indicating that the questionnaire has good content validity.

Descriptive Statistics

As described in the preceding section on questionnaire data collection, 1,080 questionnaires were distributed and 1,080 were returned. Prior to conducting mathematical statistics, the collected data underwent organization and validity analysis. Blank questionnaires and those with obviously random or inconsistent responses—such as contradictory answers or questionnaires where all selections were identical—were excluded. Ultimately, 895 valid questionnaires were confirmed, representing an 82.59% response rate. Descriptive statistics results are presented in Tables 4.3 and 4.4.

Table 4.3 Descriptive Statistics of the Questionnaire

		Sample size	Percentage
Gender	Male	208	23.24%
	Female	687	76.76%
	Subtotal	895	100%
Grade	First grade	197	22.01%
	Second grade	232	25.92%
	Third grade	268	29.94%
	Fourth grade	198	22.12%
	Subtotal	895	100%
Major	Marketing	168	18.77%
	International trade	63	7.04%
	Internet finance	152	16.98%
	Economic Management	58	6.48%
	E-commerce	122	13.63%
	Business Administration	132	14.75%
	Logistics Management	107	11.96%
	Accounting	63	7.04%
	Other majors	30	3.35%
	Subtotal	895	100%
School	Shenyang University of Technology	106	11.84%
	Shenyang University of Chemical Technology	97	10.84%
	Shenyang University of Technology	200	22.35%
	Liaoyang Branch of Shenyang University of Technology	107	11.96%
	Liaoyang Construction Vocational and Technical College	202	22.57%
	Liaoyang Technician College	184	20.56%
	Subtotal	**895**	**100%**

During the questionnaire survey, a structured questionnaire was administered to all undergraduate students in the sample group to ensure representativeness. As shown in Table 4.3, the sample was evenly distributed across the four academic years, with each cohort accounting for approximately one-quarter of the total sample size. This proportional distribution ensured that the questionnaire feedback reflected the perspectives and average educational level of the entire student body. The sample was distributed relatively evenly across six schools, enhancing the reliability of the analysis and minimizing bias in interpreting views on the operational status of the SPOC teaching model across institutions of varying tiers. The sample spanned eight management-related majors and one non-related major offering the elective course "Marketing," with this broad disciplinary distribution enhancing representativeness while maintaining equal sample sizes.

Table 4.4 Descriptive Statistics for Each Measurement Variable in the Questionnaire

Latent variables (Dimension)	**Title (Element)**	**Sample size N**	**Minimal value**	**Maximum value**	**Mean M**	**Standard deviation SD**
Behavioral Engagement	BE1	895	1	5	4.12	0.78
	BE2	895	1	5	4.05	0.81
	BE3	895	1	5	4.08	0.79
	BE4	895	1	5	4.02	0.82
	BE5	895	1	5	4.15	0.76
	Subtotal	895	1	5	4.08	0.79
Interactional engagement	IE1	895	1	5	3.52	0.95
	IE2	895	1	5	3.48	0.98
	IE3	895	1	5	3.55	0.93
	Subtotal	895	1	5	3.52	0.95

Table 4.4 (Continued)

Latent variables (Dimension)	Title (Element)	Sample size N	Minimal value	Maximum value	Mean M	Standard deviation SD
Emotional Engagement	EE1	895	1	5	3.85	0.88
	EE2	895	1	5	3.90	0.85
	EE3	895	1	5	3.92	0.84
	Subtotal	895	1	5	3.89	0.86
Cognitive Engagement	CE1	895	1	5	3.78	0.89
	CE2	895	1	5	3.82	0.87
	CE3	895	1	5	3.88	0.85
	CE4	895	1	5	3.80	0.88
	Subtotal	895	1	5	3.82	0.87

The data of latent variables in the questionnaire were statistically processed and analyzed, and the results are shown in Table 4.4. From the statistical results, it can be seen that the mean of behavioral engagement is relatively high (M=4.08, SD=0.79), the mean of Interactional engagement is relatively low (M=3.52, SD=0.95), and the mean difference between emotional engagement and cognitive engagement is not large (M=3.89, SD=0.86 vs M=3.82, SD=0.87), but the overall part is relatively balanced.

Reliability and validity test

In order to ensure the quality and internal consistency of the student questionnaire used in the first phase, we conducted reliability analysis and validity test. These tests are aimed at confirming that the questionnaire is suitable for measuring students' true views on the online and offline hybrid teaching model based on the SPOC platform.

Reliability is usually used to evaluate the stability, consistency and reliability of the data obtained from the questionnaire. The internal consistency is usually used to indicate the reliability of the questionnaire. The reliability test of this study uses Cronbach's α coefficient, combined reliability (CR) value and average variance extracted (AVE).

There is a relatively consistent standard for classifying Cronbach's α coefficients. It is generally agreed that a reliability coefficient exceeding 0.9 indicates very good reliability; between 0.7 and 0.9, relatively good reliability; between 0.6 and 0.7, acceptable reliability; and a coefficient less than 0.6 indicates very poor reliability and is recommended for discarding. The composite reliability (CR) value is the combination of the reliabilities of all indicator variables within a latent variable, indicating the internal consistency of the latent variable. Similar to Cronbach's α, higher CR values indicate greater internal consistency of the latent variable.

Hair (1997) recommends a CR value greater than 0.7, while Fornell and Larcker (1981) consider a value above 0.6 sufficient. This study considers a CR value greater than 0.6 to indicate acceptable consistency of indicators within the latent variable, while a CR value greater than 0.7 indicates good consistency within the dimensions. The variance extracted (AVE) is a measure of the explanatory power of the latent variable. A higher AVE indicates a higher reliability and convergent validity of the latent variable. Fornell and Larcker (1981) believe that the ideal AVE is greater than 0.5. Reliability is determined based on the aforementioned α coefficient, CR value, and AVE criteria. First, the overall α value of the questionnaire is calculated, followed by the α coefficient, CR value, and AVE for each latent variable. The overall α value is 0.946, indicating very good overall reliability. The correlation analysis in this study is shown in Table 4.5. The Cronbach's α coefficients of the latent variables of the compiled evaluation tools are all between 0.871 and 0.907, the CR values are between 0.873 and 0.908, and the variation extracted (AVE) is between 0.580 and 0.748, all of which meet the above standards and requirements, indicating that the reliability coefficient of the measurement questionnaire is good, that is, the measurement model has a good reliability coefficient.

Table 4.5 Reliability analysis results of each dimension of the questionnaire

Latent variables	Title	UNSTD	S.E.	C.R.	P	STD.	SMC	1-SMC	CR	AVE	Cronbach's α
Behavioral	BE1	1.000				0.719	0.517	0.483	0.873	0.580	0.871
Engagement	BE2	1.051	0.059	17.945	***	0.747	0.558	0.442			
	BE3	0.960	0.050	19.018	***	0.796	0.634	0.366			
	BE4	1.080	0.057	18.915	***	0.791	0.626	0.374			
	BE5	0.975	0.054	18.064	***	0.753	0.567	0.433			
Interactional	IE1	1.000				0.894	0.799	0.201	0.899	0.748	0.898
engagement	IE2	1.033	0.035	29.529	***	0.897	0.805	0.195			
	IE3	0.882	0.034	25.795	***	0.800	0.640	0.360			
Emotional	EE1	1.000				0.878	0.771	0.229	0.895	0.739	0.894
Engagement	EE2	0.963	0.035	27.655	***	0.878	0.771	0.229			
	EE3	0.904	0.035	25.826	***	0.822	0.676	0.324			
Cognitive	CE1	1.000				0.873	0.762	0.238	0.908	0.713	0.907
Engagement	CE2	1.029	0.034	30.270	***	0.888	0.789	0.211			
	CE3	0.883	0.032	27.409	***	0.833	0.694	0.306			
	CE4	0.911	0.037	24.556	***	0.779	0.607	0.393			

Note: P indicates the significance level of the parameter estimate. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Reliability and Validity Testing

To assess the construct validity and suitability of the dataset for confirmatory factor analysis (CFA), convergent and discriminant validity tests were conducted.

Validity is an important indicator of the scientific validity of an assessment instrument and refers to the degree to which the assessment results are valid. In other words, the extent to which the assessment instrument can truly assess the trait it is intended to measure. Generally, validation tests for assessment instruments include convergent and discriminant validity tests.

Convergent validity is primarily determined by the composite reliability (CR) and average variance extracted (AVE) values of each latent variable, as well as the

factor loading (STD) of each indicator variable. For confirmatory factor analysis, the factor loadings of the indicator variables must all be greater than or equal to 0.6; for exploratory factor analysis, the factor loadings of the measurement items can be greater than or equal to 0.5. This study draws on a well-established learning engagement scale developed by scholars both domestically and internationally. Therefore, confirmatory factor analysis was employed, requiring factor loadings to be greater than or equal to 0.6. At the same time, the combined reliability of each variable is greater than 0.6, and the value of each variable is greater than 0.5, indicating good convergent validity. This study used structural equation modeling software for analysis, and the results are shown in Table 4.5. As shown in Table 4.5, the factor loadings of all measurement items (elements) are greater than or equal to 0.719, the combined reliability of each latent variable (dimension) is greater than or equal to 0.873, and the average variance extracted is greater than 0.580, indicating that the measurement model has good convergent validity.

Discriminant validity is primarily assessed by analyzing the relationship between the square root value of the latent variable AVE and its correlation coefficient with other latent variables. If the square root value of the average variance extracted (AVE) of a latent variable is greater than the correlation coefficient with other latent variables, it indicates that this variable has good discriminant validity with other variables. Confirmatory factor analysis can determine the correlation coefficients between latent variables. The confirmatory factor analysis model for the SPOC learning engagement assessment tool for college students is shown in Figure 4.1. Among them, the chi-square value was 272.57; the ratio of chi-square to degrees of freedom was 3.245, which was within the acceptable range; GFI (0.948), AGFI (0.926), NFI (0.964), RFI (0.955), IFI (0.975), TLI (0.969), and CFI (0.975) were all greater than 0.9; RMR (0.048) and SRMR (0.027) were both less than 0.05; the RMSEA value (0.058) was less than 0.08, which was within the acceptable range; PGFI (0.664) and PNF (I 0.771) were both greater than 0.5; the CAIC value of the theoretical model (543.047) was smaller than the CAIC values of the independent model (7763.047) and the saturated model (901.588). Overall, the model fit is good. The

relationship between the specific latent variable correlation coefficients and the square root of the AVE values is shown in Table 4.6. The bold values on the diagonal are the square roots of the average variance extracted (AVE), and the values below the diagonal are the correlation coefficients of these variables with other variables. Table 4.6 shows that the square root of the AVE for each latent variable in the assessment tool is greater than the off-diagonal values in the same row and column, indicating that the assessment tool has good discriminant validity.

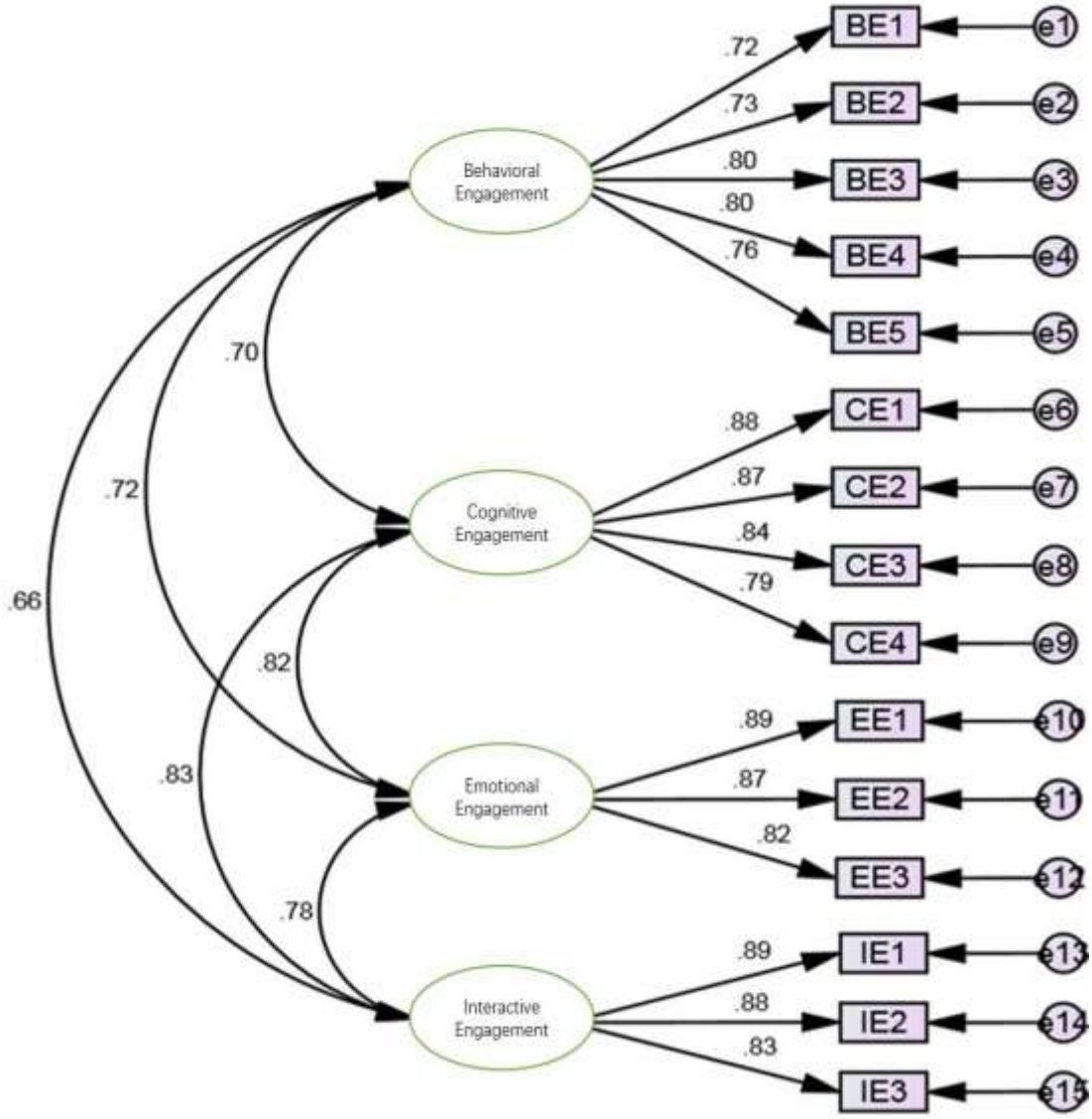

Figure 4.1 Confirmatory Factor Analysis Model of the SPOC Learning Engagement Evaluation Tool for College Students.

Table 4.6 Questionnaire Discriminant Validity Test Results

	Cognitive Engagement	Interactional Engagement	Behavioral Engagement	Emotional Engagement
Cognitive Engagement	0.844			
Interactional Engagement	0.829	0.865		
Behavioral Engagement	0.705	0.658	0.762	
Emotional Engagement	0.822	0.777	0.722	0.860

Note: The bold diagonal value is the square root of AVE.

The analysis of Tables 4.5 and 4.6 reveals two conclusions: they demonstrate a good understanding and recognition of the SPOC-based blended learning model among university students, and a strong appreciation of the dimensions and element structure of student learning engagement. The high reliability can be interpreted as indicating a high degree of student acceptance of learning on the SPOC platform, a belief that the current learning situation is acceptable, and a relatively high level of learning engagement. Convergent and discriminant validity demonstrate that the design and selection of the dimensions and element structure within the learning engagement evaluation model align with students' current learning status, enabling a relatively accurate assessment of their learning engagement.

Summary of Phase 1 Findings

The results of the first phase of research provide a clear and compelling rationale for developing a learning engagement assessment model for students using the SPOC platform in blended learning.

Extensive analysis of student questionnaire responses revealed strong interest in SPOC platform instruction, with strong behavioral engagement, slightly weaker Interactional engagement, and comparable cognitive and emotional engagement. This suggests that increasing engagement contributes to achieving learning outcomes.

Although most students reported limited previous exposure to this type of learning engagement assessment, they demonstrated a good understanding of the

dimensions and elements of engagement assessment and fully endorsed their structure. They also believed that learning engagement assessment contributes to achieving course objectives and learning outcomes. Reliability and validity testing confirmed the questionnaire's internal consistency and suitability for factor analysis.

Four key assessment dimensions were identified: behavioral engagement, Interactional engagement, cognitive engagement, and emotional engagement, laying a solid foundation for designing the assessment model.

Findings Related to Objective 2 – To developing and Refining a Learning Engagement Evaluation Model for Blended Learning on the SPOC Platform

After determining the dimensions and elements of learning engagement evaluation in the first phase, the research entered the second phase. This phase primarily involved conducting a structural equation model fit test based on the theoretical model for evaluating college students' SPOC learning engagement, initially constructed earlier, and the collected measured data. Valid questionnaire data was imported into structural equation modeling software software and a structural equation calculation was performed. The model fit index was then used to determine whether the structural model fit index met the required fit criteria, thereby demonstrating the structural model's fit and determining its suitability for evaluation.

Verification of the original model A

Based on the theoretical research results in Chapter 2, the theoretical model construction process focuses on the Engagement of the four dimensions of behavior, Interactional, cognition, and emotion. Assumptions are made on the structural relationship between them, and the evaluation model A of college students' SPOC learning engagement as shown in Figure 4.2 is drawn as the basic model. The theoretical model contains four latent variables, namely behavioral engagement, Interactional engagement, cognitive engagement, and emotional engagement. Here, the hypothesis is proposed that the influence of other variables on Interactional

engagement is not considered, and only the degree of its influence on other variables is considered. Therefore, Interactional engagement is an exogenous latent variable and no residual term is required. Behavioral engagement, cognitive engagement, and emotional engagement are all affected by other variables, so they are endogenous latent variables and a residual term is required.

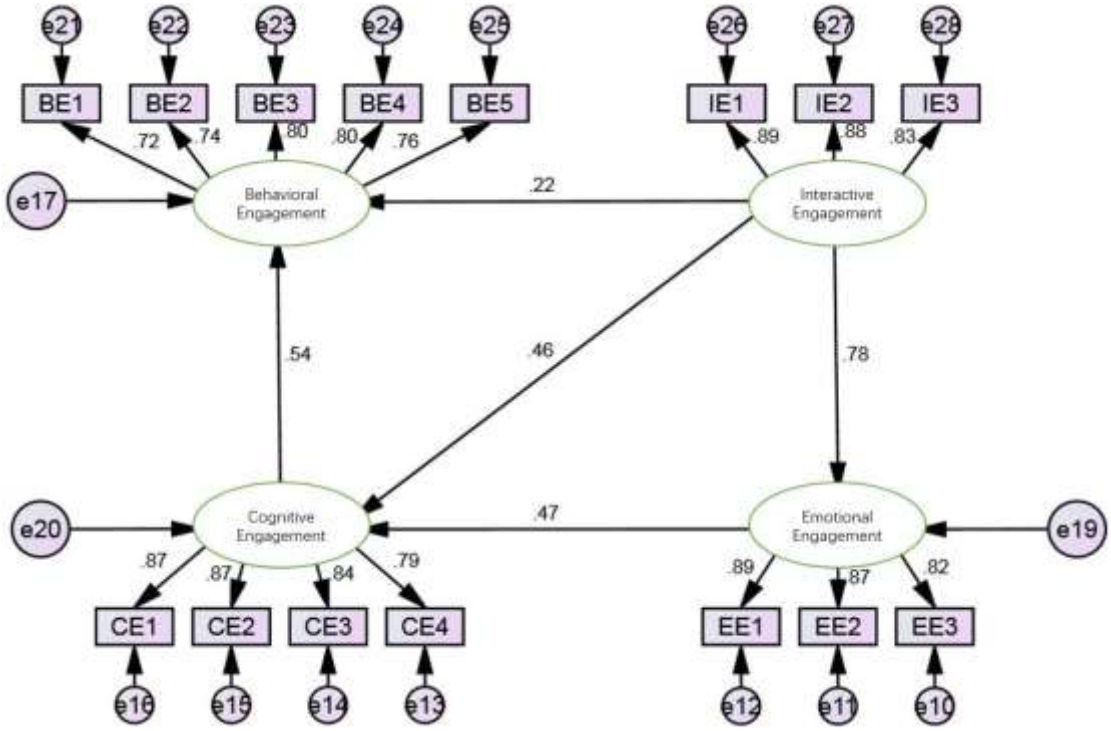

Figure 4.2 Evaluation Model A for College Students' SPOC Learning Engagement

The goodness of fit of evaluation model A was identified and tested. The valid data collected from the questionnaires were imported into structural equation modeling software, and structural equation calculations were performed to obtain the fit indices for model A. The details are as follows: The standardized factor loadings of the indicator variables, the variances between the exogenous variables, the unstandardized regression coefficients and their significance tests, and the inter-variable correlation coefficient matrix for model A are shown in Tables 4.7, 4.8, 4.9, and 4.10, respectively. Table 4.7 shows that the factor loading coefficients for the

indicator variables all range from 0.718 to 0.880, falling within the range of 0.50 to 0.95, meeting the fit requirements. Table 4.8 shows that the error variances in model A are all greater than 0.027, with no negative values. Table 4.9 shows that all error variance coefficients (CRs) range from 3.11 to 31.301, all exceeding 1.96, reaching the significance level. The standard errors of the estimated parameters range from 0.033 to 0.069, showing relatively small standard errors. Table 4.10 shows that the absolute values of the correlation coefficients between all variables are less than 0.888, meeting the rule that absolute values should be too close to 1. This indicates that Model A has generally good intrinsic quality. Therefore, Model A meets the basic model fit requirements, and further analysis of the overall model fit is warranted.

Table 4.7 Summary of Standardized Factor Loadings of Indicator Variables in Model A

Path			Estimate
EE3	<---	Emotional Engagement	0.817
EE2	<---	Emotional Engagement	0.873
EE1	<---	Emotional Engagement	0.886
CE4	<---	Cognitive Engagement	0.786
CE3	<---	Cognitive Engagement	0.843
CE2	<---	Cognitive Engagement	0.869
CE1	<---	Cognitive Engagement	0.873
BE1	<---	Behavioral Engagement	0.718
BE2	<---	Behavioral Engagement	0.738
BE3	<---	Behavioral Engagement	0.795
BE4	<---	Behavioral Engagement	0.795
BE5	<---	Behavioral Engagement	0.759
IE1	<---	Interactional Engagement	0.888
IE2	<---	Interactional Engagement	0.880
IE3	<---	Interactional Engagement	0.827

Table 4.8 Variance and significance tests among exogenous variables in Model

Exogenous variables	Estimate	S.E.	C.R.	P
Interactional Engagement	1.58	0.11	14.344	***
e19	0.453	0.043	10.601	***
e20	0.256	0.027	9.398	***
e17	0.425	0.045	9.407	***
e10	0.563	0.038	14.87	***
e11	0.417	0.032	13.007	***
e12	0.391	0.033	11.977	***
e13	0.68	0.042	16.077	***
e14	0.43	0.029	14.952	***
e15	0.42	0.03	13.856	***
e16	0.402	0.029	13.734	***
e21	0.907	0.057	15.907	***
e22	0.886	0.056	15.685	***
e23	0.521	0.036	14.443	***
e24	0.658	0.046	14.345	***
e25	0.693	0.045	15.266	***
e26	0.426	0.035	12.065	***
e27	0.474	0.038	12.423	***
e28	0.615	0.042	14.741	***

Note: P represents the significance level of the estimated parameter. * $P < 0.05$, ** $P < 0.01$, ***$P < 0.001$.

Table 4.9 Summary of Unstandardized Regression Coefficients and Significance Tests in Model A

Path	Estimate	S.E.	C.R.	P
Emotional<---Interactional Engagement	0.665	0.033	19.868	***
Cognitive<---Emotional Engagement	0.465	0.048	9.66	***
Cognitive<---Interactional Engagement	0.385	0.04	9.569	***
Behavioral<---Cognitive Engagement	0.507	0.069	7.352	***
Behavioral<---Interactional Engagement	0.17	0.055	3.11	0.002
EE3<---Emotional Engagement	1			
EE2<---Emotional Engagement	1.065	0.04	26.68	***
EE1<---Emotional Engagement	1.122	0.041	27.187	***
CE4<---Cognitive Engagement	1			
CE3<---Cognitive Engagement	0.972	0.04	24.372	***
CE2<---Cognitive Engagement	1.095	0.043	25.35	***
CE1<---Cognitive Engagement	1.087	0.043	25.492	***
BE1<--- Behavioral Engagement	1			
BE2<--- Behavioral Engagement	1.039	0.058	17.985	***
BE3<--- Behavioral Engagement	0.96	0.05	19.318	***
BE4<--- Behavioral Engagement	1.087	0.056	19.323	***
BE5<--- Behavioral Engagement	0.985	0.053	18.488	***
IE1<--- Interactional Engagement	1			
IE2<--- Interactional Engagement	1.02	0.033	31.301	***
IE3<--- Interactional Engagement	0.917	0.033	28.017	***

Note: P indicates the significance level of the estimated regression coefficient. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 4.10 Correlation coefficient matrix between variables in Model A

	Interactional Engagement	Emotional Engagement	Cognitive Engagement	Behavioral Engagement	IE3	IE2	IE1	BE5	BE4	BE3	BE2	BE1	CE1	CE2	CE3	CE4	EE1	EE2	EE3
Interactional Engagement	1																		
Emotional Engagement	0.781	1																	
Cognitive Engagement	0.83	0.833	1																
Behavioral Engagement	0.666	0.62	0.721	1															
IE3	0.827	0.645	0.686	0.551	1														
IE2	0.88	0.687	0.73	0.586	0.728	1													
IE1	0.888	0.693	0.737	0.592	0.734	0.781	1												
BE5	0.506	0.471	0.548	0.759	0.418	0.445	0.449	1											
BE4	0.53	0.493	0.574	0.795	0.438	0.466	0.471	0.604	1										
BE3	0.53	0.493	0.573	0.795	0.438	0.466	0.47	0.604	0.632	1									
BE2	0.492	0.458	0.532	0.738	0.406	0.433	0.437	0.56	0.587	0.587	1								
BE1	0.478	0.445	0.518	0.718	0.395	0.421	0.425	0.545	0.571	0.571	0.53	1							
CE1	0.724	0.727	0.873	0.629	0.599	0.637	0.643	0.478	0.5	0.5	0.464	0.452	1						
CE2	0.721	0.724	0.869	0.627	0.596	0.635	0.64	0.476	0.498	0.498	0.462	0.45	0.758	1					
CE3	0.7	0.702	0.843	0.608	0.579	0.616	0.621	0.462	0.484	0.483	0.449	0.437	0.736	0.732	1				
CE4	0.652	0.655	0.786	0.567	0.539	0.574	0.579	0.43	0.451	0.451	0.418	0.407	0.686	0.683	0.662	1			
EE1	0.692	0.886	0.738	0.55	0.572	0.609	0.614	0.417	0.437	0.437	0.405	0.395	0.644	0.641	0.622	0.58	1		
EE2	0.682	0.873	0.727	0.542	0.564	0.6	0.605	0.411	0.431	0.431	0.4	0.389	0.635	0.632	0.613	0.572	0.774	1	
EE3	0.638	0.817	0.681	0.507	0.528	0.562	0.567	0.385	0.403	0.403	0.374	0.364	0.594	0.591	0.574	0.535	0.724	0.714	1

The above analysis shows that Model A meets the basic model fit standards and requirements. We now need to analyze the overall model fit of Model A, as shown in Table 4.11. The degrees of freedom are 85, the chi-square value is 306.508, the P value is 0.000 < 0.05, and the chi-square to degrees of freedom ratio is 3.606, which is greater than 3 and less than 5. Preliminary evaluation indicates that Model A can be basically identified. In addition, further analysis is needed in combination with other fitting indicators. The GFI value of model A is 0.942, AGFI value is 0.918, SRMR value is 0.036, IFI value is 0.971, RMSEA value is 0.062, NFI value is 0.960, RFI value is 0.951, IFI value is 0.971, TLI value is 0.964, CFI value is 0.971, PGFI value is 0.667, PNFI value is 0.777, and the CAIC value of the theoretical model is 569.471, which is smaller than the CAIC value of the saturated model (901.588) and the CAIC value of the independent model (7763.047). Except for the RMR value of 0.064, which is slightly higher than the critical value of 0.05, all other fitting indicators meet the adaptation standard. Overall, since the questionnaire sample size is as high as 895, the chi-square value is easily affected by the sample size, but the ratio of chi-square to degrees of freedom and the RMSEA value are within an acceptable range.

Table 4.11 Fitting index parameters of evaluation model A

	Fit index	**Fitting Standard**	**Measured values**	**Results Evaluation**
Absolute fit index	x2	The significance probability value p is greater than 0.05 (not reaching the significance level).	306.508 (P=0.000)	For reference only
	GFI	≥0.90	0.942	Good fit
	AGFI	≥0.90	0.918	Good fit
	RMR	≤0.05	0.064	Unsatisfied
	SRMR	≤0.05	0.036	Good fit
	RMSEA	≤0.05(Good fit) 0.05~0.08 (Acceptable)	0.062	Acceptable standards

Table 4.11 Fitting index parameters of evaluation model A

	Fit index	Fitting Standard	Measured values	Results Evaluation
Value-added adaptability index	NFI	≥0.90	0.960	Good fit
	RFI	≥0.90	0.951	Good fit
	IFI	≥0.90	0.971	Good fit
	TLI	≥0.90	0.964	Good fit
	CFI	≥0.90	0.971	Good fit
Simplicity Adaptability Index	PGFI	≥0.50	0.667	Good fit
	PNFI	≥0.50	0.777	Good fit
	NC (x2/df)	1-3 (Good fit) 3-5 (Acceptable) 5 and above (Model needs modification)	3.606	Acceptable standards
	CAIC	The CAIC value of the theoretical model is less than the CAIC value of the independent model, and less than the CAIC value of the saturated model.	569.471 (Theoretical Model) 901.588 (Saturated Model) 7763.047 (Independent Model)	Good fit

In summary, Model A generally meets the fit criteria, but further refinement is possible. Model A was modified using the correction indicators. The regression coefficient correction indicator suggests adding the path of the influence of emotional engagement on behavioral engagement. The specific correction parameters are shown in Table 4.12. Based on practical experience, in online and

offline hybrid courses based on the SPOC platform, learners' participation in course activities is an important manifestation of their emotional engagement. Behavioral engagement is an outward manifestation of college students' emotional expression.

Therefore, the correction indicator suggestion can be accepted, adding the path relationship between emotional engagement and behavioral engagement.

Table 4.12 Regression coefficient correction indicator parameters

Path	Modify the metric value	Estimate the parameter change value
Behavioral Engagement<--- Emotional Engagement	6.541	0.75

Tests of Modified Model B

Because Model A has suboptimal fit indicators and provides feasible correction indicators, we now add a reasonable path relationship (emotional engagement - behavioral engagement). After correction, we obtain Model B, as shown in Figure 4.3. The same identification and testing procedures and steps as for Model A were repeated to obtain the identification indicators and fit of Model B. The specific results are as follows.

Based on the basic fit requirements of structural equation models, we first assess and analyze the basic fit of Model B. Tables 4.13, 4.14, 4.15, and 4.16 show that the factor loading coefficients of the indicator variables in Model B range from 0.50 to 0.95, meeting the fit criteria. The error variance values are all greater than 0, with no negative values. With the exception of the error variance coefficient (C.R.) for the Interactional engagement to behavioral engagement path, which is 1.608 and less than 1.96, all other C.R. values range from 3.45 to 31.339, exceeding 1.96 and reaching a significant level. The error variance parameter for the Interactional-to-behavior Engagement path violates estimation, requiring a comprehensive analysis combining unstandardized regression coefficients and significance. Furthermore, the

absolute values of the correlation coefficients between variables are all less than 0.888, which does not violate the rule that absolute values are too close to 1, indicating that Model B has generally good intrinsic quality.

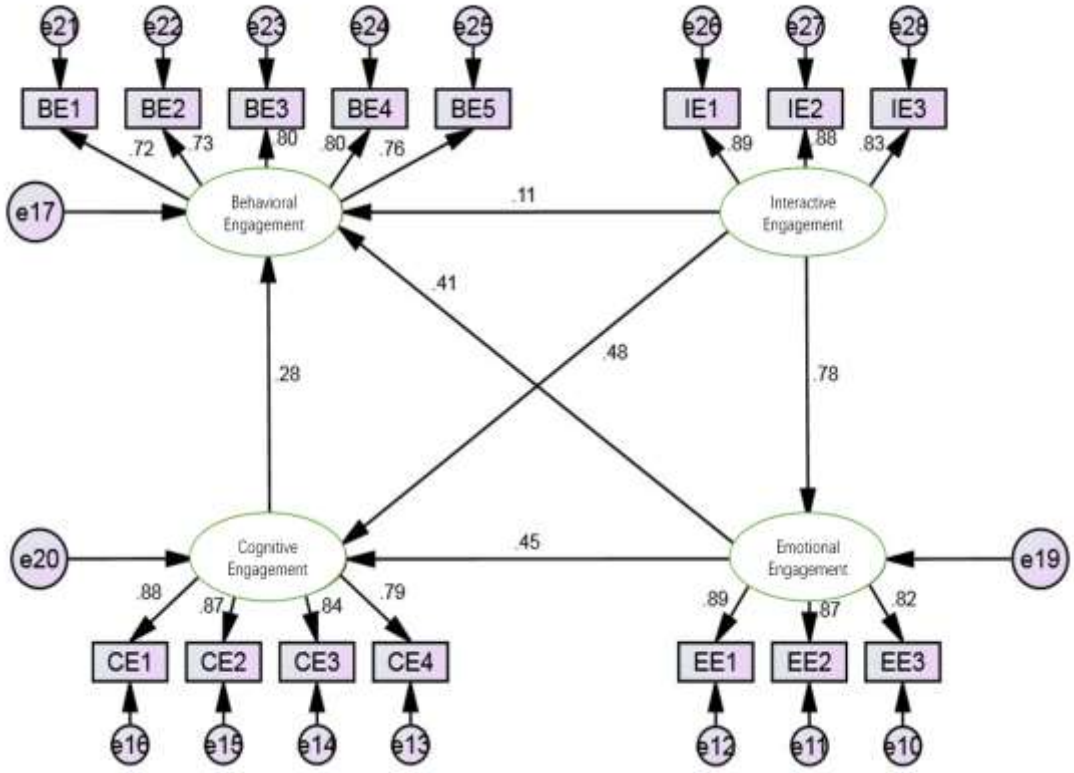

Figure 4.3 Evaluation Model B for College Students' SPOC Learning Engagement

Table 4.13 Summary of standardized factor loadings of indicator variables in Model B

Path	Estimate
EE3<--- Emotional Engagement	0.82
EE2<--- Emotional Engagement	0.87
EE1<--- Emotional Engagement	0.887
CE4<--- Cognitive Engagement	0.787
CE3<--- Cognitive Engagement	0.841
CE2<--- Cognitive Engagement	0.873

Table 4.13 (Continued)

Path	Estimate
CE1<--- Cognitive Engagement	0.875
BE1<--- Behavioral Engagement	0.719
BE2<--- Behavioral Engagement	0.735
BE3<--- Behavioral Engagement	0.795
BE4<--- Behavioral Engagement	0.798
BE5<--- Behavioral Engagement	0.758
IE1<--- Interactional Engagement	0.888
IE2<--- Interactional Engagement	0.881
IE3<--- Interactional Engagement	0.827

Table 4.14 Variance and significance tests among exogenous variables in Model B

Exogenous variables	Estimate	S.E.	C.R.	P
Interactional Engagement	1.582	0.11	14.362	***
e19	0.458	0.043	10.614	***
e20	0.257	0.027	9.404	***
e17	0.426	0.045	9.431	***
e10	0.562	0.038	14.845	***
e11	0.414	0.032	12.939	***
e12	0.393	0.033	11.976	***
e13	0.681	0.042	16.072	***
e14	0.43	0.029	14.933	***
e15	0.418	0.03	13.81	***
e16	0.401	0.029	13.691	***
e21	0.908	0.057	15.918	***
e22	0.885	0.056	15.684	***
e23	0.52	0.036	14.428	***

Table 4.14 (Continued)

Exogenous variables	Estimate	S.E.	C.R.	P
e24	0.659	0.046	14.361	***
e25	0.694	0.045	15.276	***
e26	0.424	0.035	12.033	***
e27	0.476	0.038	12.466	***
e28	0.616	0.042	14.751	***

Note: P indicates the significance level of the estimated variance parameter. * p < 0.05, ** p < 0.01, *** p < 0.001.

Table 4.15 Summary of unstandardized regression coefficients and significance tests in Model B

Path	Estimate	S.E.	C.R.	P
Emotional Engagement <--- Interactional Engagement	0.663	0.033	19.818	***
Cognitive Engagement <--- Emotional Engagement	0.439	0.048	9.223	***
Cognitive Engagement <--- Interactional Engagement	0.402	0.04	9.943	***
Behavioral Engagement <--- Cognitive Engagement	0.26	0.075	3.45	***
Behavioral Engagement <--- Interactional Engagement	0.088	0.055	1.608	0.108
Behavioral Engagement <--- Emotional Engagement	0.373	0.065	5.737	***
EE3<--- Emotional Engagement	1			
EE2<--- Emotional Engagement	1.058	0.04	26.77	***
EE1<--- Emotional Engagement	1.119	0.041	27.454	***

Table 4.15 (Continued)

Path	Estimate	S.E.	C.R.	P
CE4<--- Cognitive Engagement	1			
CE3<--- Cognitive Engagement	0.969	0.04	24.307	***
CE2<--- Cognitive Engagement	1.099	0.043	25.509	***
CE1<--- Cognitive Engagement	1.089	0.043	25.61	***
BE1<--- Behavioral Engagement	1			
BE2<--- Behavioral Engagement	1.033	0.057	17.978	***
BE3<---Behavioral Engagement	0.958	0.049	19.401	***
BB4<---Behavioral Engagement	1.088	0.056	19.458	***
BE5<--- Behavioral Engagement	0.981	0.053	18.533	***
IE1<--- Interactional Engagement	1			
IE2<--- Interactional Engagement	1.022	0.033	31.339	***
IE3<--- Interactional Engagement	0.917	0.033	28.017	***

Note: P indicates the significance level of the estimated regression coefficient. * P < 0.05, ** P < 0.01, *** P < 0.001.

Table 4.16 Correlation coefficient matrix between variables in Model B

	Interactional Engagement	Emotional Engagement	Cognitive Engagement	Behavioral Engagement	IE3	IE2	IE1	BE5	BE4	BE3	BE2	BE1	CE1	CE2	CE3	CE4	EE1	EE2	EE3
Interactional Engagement	1																		
Emotional Engagement	0.779	1																	
Cognitive Engagement	0.831	0.822	1																
Behavioral Engagement	0.631	0.724	0.709	1															
IE3	0.827	0.645	0.688	0.522	1														
IE2	0.882	0.687	0.733	0.556	0.729	1													
IE1	0.887	0.692	0.738	0.56	0.734	0.782	1												
BE5	0.479	0.549	0.538	0.758	0.396	0.422	0.425	1											
BE4	0.504	0.578	0.566	0.798	0.417	0.444	0.447	0.605	1										
BE3	0.501	0.575	0.563	0.794	0.415	0.442	0.445	0.602	0.634	1									
BE2	0.464	0.532	0.521	0.735	0.383	0.409	0.411	0.557	0.586	0.584	1								
BE1	0.454	0.521	0.51	0.72	0.376	0.401	0.403	0.546	0.574	0.572	0.529	1							
CE1	0.727	0.719	0.875	0.62	0.601	0.641	0.645	0.47	0.495	0.493	0.456	0.446	1						
CE2	0.725	0.717	0.872	0.618	0.6	0.639	0.643	0.469	0.493	0.491	0.454	0.445	0.763	1					
CE3	0.699	0.691	0.841	0.596	0.578	0.616	0.62	0.452	0.476	0.474	0.438	0.429	0.736	0.733	1				
CE4	0.654	0.647	0.787	0.558	0.541	0.577	0.581	0.423	0.445	0.443	0.41	0.402	0.688	0.686	0.662	1			
EE1	0.691	0.887	0.729	0.643	0.572	0.609	0.614	0.487	0.513	0.51	0.472	0.463	0.638	0.636	0.613	0.574	1		
EE2	0.677	0.869	0.715	0.63	0.56	0.597	0.601	0.477	0.502	0.5	0.463	0.453	0.625	0.623	0.601	0.563	0.771	1	

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The intrinsic quality of Model B generally meets the standards, but further analysis of its overall fit is required. Specific fit indices are shown in Table 4.17. The data demonstrate that, with the exception of the chi-square value, which was affected by the large sample size and therefore not ideal, all other fit indices met the requirements. Comprehensive judgment analysis indicates that Model B has generally satisfactory overall fit and can be used to evaluate the relationships within the internal structure of university students' SPOC learning engagement. Due to the error variance parameter of the path from Interactional engagement to behavioral engagement being estimated, analysis of the path regression coefficients revealed that all path coefficients were positive. However, while the path relationships between Interactional engagement and emotional engagement, cognitive engagement, emotional engagement, cognitive engagement, behavioral engagement, and cognitive engagement, and cognitive engagement and behavioral engagement reached significance, the path value for the impact of Interactional engagement on behavioral engagement was 0.088 (unstandardized), with a P value of 0.108, greater than 0.05, but not significant. This also suggests that further revisions to Model B are needed.

Table 4.17 Fitting index parameters of evaluation model B

	Fit index	**Fitting Standard**	**Measured values**	**Results Evaluation**
Absolute fit index	x2	The significance probability value p is greater than 0.05 (not reaching the significance level).	272.570 (P=0.000)	For reference only
	GFI	≥0.90	0.948	Good fit
	AGFI	≥0.90	0.926	Good fit
	RMR	≤0.05	0.048	Good fit
	SRMR	≤0.05	0.027	Good fit

Table 4.17 (Continued)

	Fit index	Fitting Standard	Measured values	Results Evaluation
	RMSEA	≤0.05(Good fit) 0.05~0.08 (Acceptable)	0.058	Acceptable standards
Value-added adaptability index	NFI	≥0.90	0.964	Good fit
	RFI	≥0.90	0.955	Good fit
	IFI	≥0.90	0.975	Good fit
	TLI	≥0.90	0.969	Good fit
	CFI	≥0.90	0.975	Good fit
Simplicity Adaptability Index	PGFI	≥0.50	0.664	Good fit
	PNFI	≥0.50	0.771	Good fit
	NC (x2/df)	1-3 (Good fit) 3-5 (Acceptable) 5 and above (Model needs modification)	3.245	Acceptable standards
	CAIC	The CAIC value of the theoretical model is less than the CAIC value of the independent model, and less than the CAIC value of the saturated model.	543.047 (Theoretical Model) 901.588 (Saturated Model) 7763.047 (Independent Model)	Good fit

Test of Modified Model C

Because Model B contained an unsatisfactory path relationship, the insignificant path relationship Interactional engagement – behavioral engagement) was deleted. After correction, Model C, shown in Figure 4.4, was obtained. Repeating the operational procedures and steps for identifying and testing Models A and B, the identification indicators and fit of Model C were obtained. The specific results are as follows.

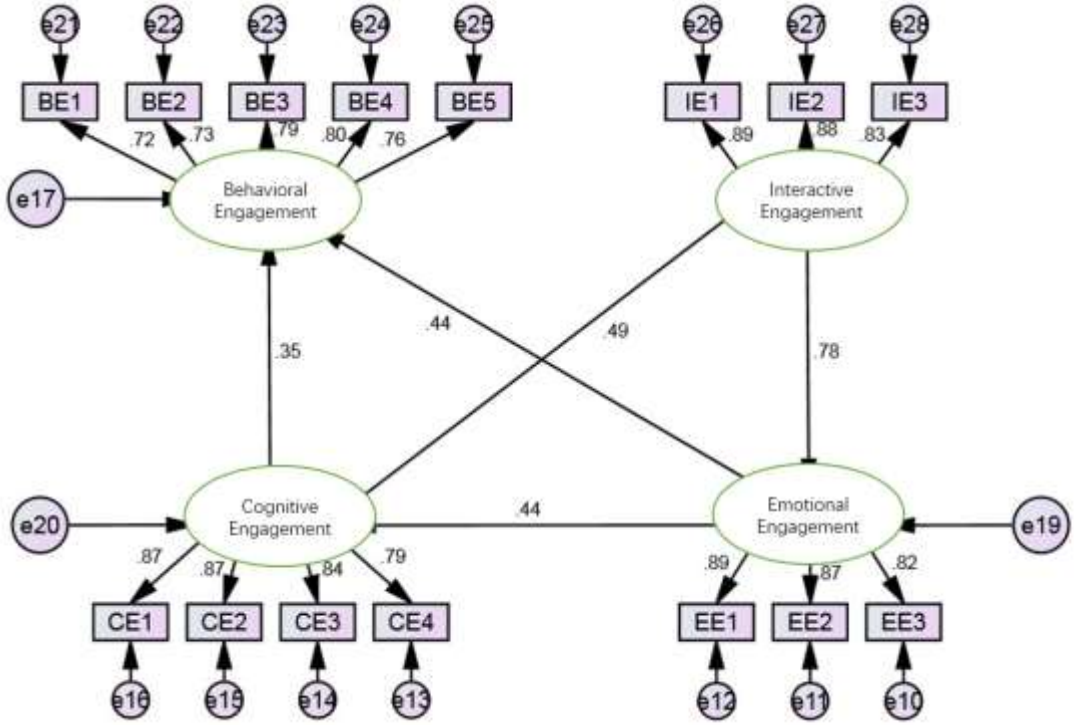

Figure 4.4 Evaluation Model C for College Students' SPOC Learning Engagement

Similar to the assessment of the fitness of Models A and B, we first assess the basic fitness of Model C. Tables 4.18, 4.19, 4.20, and 4.21 show that the factor loading coefficients of the indicator variables range from 0.50 to 0.95, the error variances are all positive, and the error variation coefficients (C.R.) are all greater than 1.96, reaching a significant level. The absolute values of the correlation coefficients between all variables are less than 0.887, not too close to 1. This comprehensive

analysis indicates that the intrinsic quality of Model C is generally ideal, and further analysis of Model C's overall fitness is warranted.

Table 4.18 Summary of standardized factor loadings for each variable in Model C

Path	Estimate
Emotional Engagement <--- Interactional engagement	0.779
Cognitive Engagement <--- Emotional Engagement	0.444
Cognitive Engagement <--- Interactional engagement	0.485
Behavioral Engagement <--- Cognitive Engagement	0.35
EE3<--- Emotional Engagement	0.82
EE2<--- Emotional Engagement	0.869
EE1<--- Emotional Engagement	0.887
CE4<--- Cognitive Engagement	0.787
CE3<--- Cognitive Engagement	0.841
CE2<--- Cognitive Engagement	0.872
CE1<--- Cognitive Engagement	0.875
BE1<--- Behavioral Engagement	0.72
BE2<--- Behavioral Engagement	0.735
BE3<--- Behavioral Engagement	0.794
BE4<--- Behavioral Engagement	0.798
BE5<--- Behavioral Engagement	0.758
IE1<--- Interactional engagement	0.887
IE2<--- Interactional engagement	0.882
IE3<--- Interactional engagement	0.827

Table 4.19 Variance and significance tests among exogenous variables in Model C

Exogenous variables	Estimate	S.E.	C.R.	P
Interactional engagement	1.58	0.11	14.344	***
e19	0.453	0.043	10.601	***
e20	0.256	0.027	9.398	***
e17	0.425	0.045	9.407	***
e10	0.563	0.038	14.87	***
e11	0.417	0.032	13.007	***
e12	0.391	0.033	11.977	***
e13	0.68	0.042	16.077	***
e14	0.43	0.029	14.952	***
e15	0.42	0.03	13.856	***
e16	0.402	0.029	13.734	***
e21	0.907	0.057	15.907	***
e22	0.886	0.056	15.685	***
e23	0.521	0.036	14.443	***
e24	0.658	0.046	14.345	***
e25	0.693	0.045	15.266	***
e26	0.426	0.035	12.065	***
e27	0.474	0.038	12.423	***
e28	0.615	0.042	14.741	***

Note: P indicates the significance level of the estimated variance parameter.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Table 4.20 Summary of unstandardized regression coefficients and significance tests in Model C is continued on the next page.

Path	Estimate	S.E.	C.R.	P
Emotional Engagement <---Interactional engagement	0.666	0.033	19.894	***
Cognitive Engagement <--- Emotional Engagement	0.435	0.048	9.1	***
Cognitive Engagement <--- Interactional Engagement	0.406	0.041	9.972	***
Behavioral Engagement <--- Cognitive Engagement	0.328	0.064	5.169	***
Behavioral Engagement <--- Interactional Engagement	0.402	0.063	6.327	***
Behavioral Engagement <--- Emotional Engagement	1			
EE3<--- Emotional Engagement	1.057	0.04	26.723	***
EE2<--- Emotional Engagement	1.12	0.041	27.461	***
EE1<--- Emotional Engagement	1			
CE4<--- Cognitive Engagement	0.968	0.04	24.323	***
CE3<--- Cognitive Engagement	1.098	0.043	25.513	***
CE2<--- Cognitive Engagement	1.088	0.042	25.618	***
CE1<--- Cognitive Engagement	1			
BE1<--- Behavioral Engagement	1.032	0.057	17.982	***
BE2<--- Behavioral Engagement	0.956	0.049	19.396	***
BE3<--- Behavioral Engagement	1.088	0.056	19.479	***
BB4<--- Behavioral Engagement	0.981	0.053	18.55	***
BE5<--- Behavioral Engagement	1			
IE1<--- Interactional Engagement	1.023	0.033	31.324	***
IE2<--- Interactional Engagement	0.918	0.033	27.991	***
IE3<--- Interactional Engagement	0.666	0.033	19.894	***

Note: P indicates the significance level of the estimated unstandardized regression coefficient. *p < 0.05, ** p < 0.01, *** p < 0.001.

Table 4.21 Correlation coefficient matrix between variables in Model C

	Interactional Engagement	Emotional Engagement	Cognitive Engagement	Behavioral Engagement	IE3	IE2	IE1	BE5	BE4	BE3	BE2	BE1	CE1	CE2	CE3	CE4	EE1	EE2	EE3
Interactional Engagement	1																		
Emotional Engagement	0.779	1																	
Cognitive Engagement	0.831	0.822	1																
Behavioral Engagement	0.631	0.724	0.709	1															
IE3	0.827	0.645	0.688	0.522	1														
IE2	0.882	0.687	0.733	0.556	0.729	1													
IE1	0.887	0.692	0.738	0.56	0.734	0.782	1												
BE5	0.479	0.549	0.538	0.758	0.396	0.422	0.425	1											
BE4	0.504	0.578	0.566	0.798	0.417	0.444	0.447	0.605	1										
BE3	0.501	0.575	0.563	0.794	0.415	0.442	0.445	0.602	0.634	1									
BE2	0.464	0.532	0.521	0.735	0.383	0.409	0.411	0.557	0.586	0.584	1								
BE1	0.454	0.521	0.51	0.72	0.376	0.401	0.403	0.546	0.574	0.572	0.529	1							
CE1	0.727	0.719	0.875	0.62	0.601	0.641	0.645	0.47	0.495	0.493	0.456	0.446	1						
CE2	0.725	0.717	0.872	0.618	0.6	0.639	0.643	0.469	0.493	0.491	0.454	0.445	0.763	1					
CE3	0.699	0.691	0.841	0.596	0.578	0.616	0.62	0.452	0.476	0.474	0.438	0.429	0.736	0.733	1				
CE4	0.654	0.647	0.787	0.558	0.541	0.577	0.581	0.423	0.445	0.443	0.41	0.402	0.688	0.686	0.662	1			
EE1	0.691	0.887	0.729	0.643	0.572	0.609	0.614	0.487	0.513	0.51	0.472	0.463	0.638	0.636	0.613	0.574	1		
EE2	0.677	0.869	0.715	0.63	0.56	0.597	0.601	0.477	0.502	0.5	0.463	0.453	0.625	0.623	0.601	0.563	0.771	1	
EE3	0.639	0.82	0.674	0.594	0.528	0.563	0.567	0.45	0.474	0.472	0.436	0.427	0.59	0.588	0.567	0.531	0.727	0.713	1

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After confirming that Model C intrinsic quality has reached an ideal state, further analysis of Model C's overall fit is required. Specific fit index values are shown in Table 4.22. With the exception of the chi-square value, which is affected by the large sample size and results in a P value less than 0.05, which is not ideal, all other fit indices meet the fit criteria. Comprehensive analysis shows that most indicators meet the requirements, indicating that Model C's overall fit is generally ideal.

Table 4.22 Fitting index parameters of evaluation model C

	Fit index	**Fitting Standard**	**Measured values**	**Results Evaluation**
Absolute fit index	x2	The significance probability value p is greater than 0.05 (not reaching the significance level).	275.124 (P=0.000)	For reference only
	GFI	≥0.90	0.948	Good fit
	AGFI	≥0.90	0.926	Good fit
	RMR	≤0.05	0.049	Good fit
	SRMR	≤0.05	0.028	Good fit
	RMSEA	≤0.05(Good fit) 0.05~0.08 (Acceptable)	0.058	Acceptable standards
Value-added adaptability index	NFI	≥0.90	0.964	Good fit
	RFI	≥0.90	0.956	Good fit
	IFI	≥0.90	0.975	Good fit
	TLI	≥0.90	0.969	Good fit
	CFI	≥0.90	0.975	Good fit
Simplicity Adaptability Index	PGFI	≥0.50	0.671	Good fit
	PNFI	≥0.50	0.780	Good fit
	NC (x2/df)	1-3 (Good fit) 3-5 (Acceptable) 5 and above (Model needs modification)	3.237	Acceptable standards

Table 4.22 (Continued)

	Fit index	Fitting Standard	Measured values	Results Evaluation
	CAIC	The CAIC value of the theoretical model is less than the CAIC value of the independent model, and less than the CAIC value of the saturated model.	538.087 (Theoretical Model) 901.588 (Saturated Model) 7763.047 (Independent Model)	Good fit

Final model and hypotheses

Based on the above analysis, we can see that most of Model C's fit indicators meet the fitting criteria and exhibit a certain degree of stability. This indicates that the revised model C for evaluating college students' SPOC learning engagement has an acceptable fit, meaning that the revised model C can be used to evaluate college students' SPOC learning engagement. Based on the comprehensive analysis, the theoretical foundation-based "Theoretical Model for Evaluating Learning Engagement in an Online and Offline Hybrid Teaching Model Based on the SPOC Platform" has been largely validated, but slight revisions and adjustments are still required. The final model for evaluating college students' SPOC learning engagement is shown in Figure 4.5

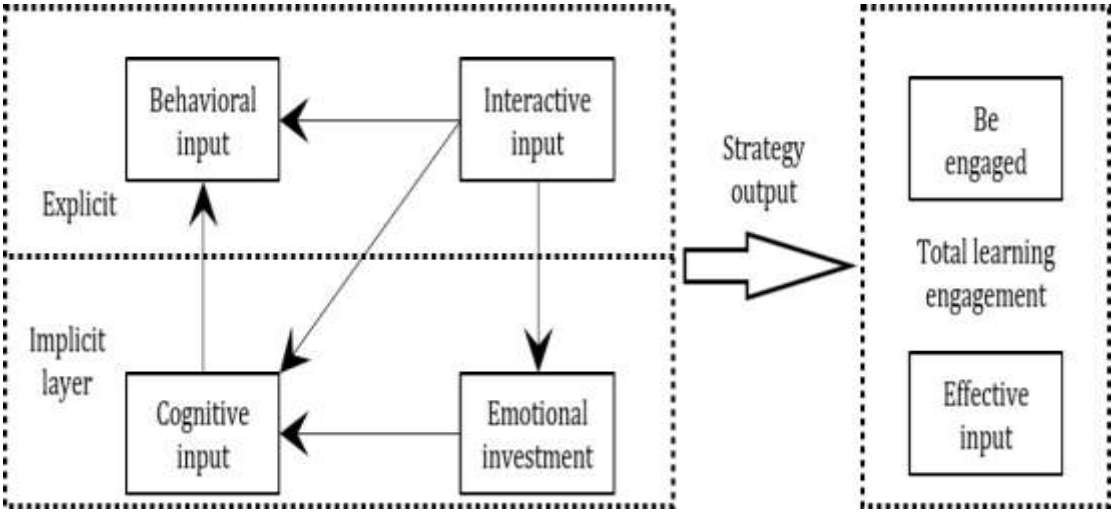

Figure 4.5 Learning engagement evaluation model for online and offline hybrid teaching based on the SPOC platform

Regarding the final evaluation model for college students' SPOC learning engagement, before moving on to Phase 3, the following clarification is necessary:

Compared to the theoretical model initially developed in Chapter 3, the final evaluation model does not yet show a significant direct impact between Interactional engagement and behavioral engagement.

Explicit Interactional engagement does influence behavioral engagement to some extent, but this effect is not significant, potentially acting as a hidden factor influencing learning behavior.

Insignificant paths were not directly deleted from the final model but retained as dashed lines. This is because, in SPOC-based learning, college students' Interactional engagement may be influenced by other Interactional variables, such as human-computer Interactional, in addition to student-student Interactional and teacher-student Interactional.

The model selects the most representative observational indicators in each dimension for field testing and does not consider the influence of other relevant

factors or variables. Therefore, dashed path relationships that do not yet show a direct significant impact will be further verified in later research.

The final model is the product of repeated refinement, based on student needs, and validated by teachers. These refinements help ensure the model is practical, pedagogically reliable, and scalable for full-course implementation in Phase 3. It can then be used in large-scale evaluations.

Summary of Phase 2 Findings

The phase 2 focused on developing and, through testing, revising a model for evaluating college students' SPOC learning engagement. This model was guided by the four dimensions and 15 factors identified in the first phase.

This phase followed the data fitting process of a structural equation model (SEM). All fit indicators met the appropriateness criteria, with generally satisfactory internal quality and overall good fit.

The model initially employed a four-dimensional structure: behavioral engagement, Interactional engagement, cognitive engagement, and emotional engagement. These four dimensions are latent variables, not directly observable but inferred through observation of other variables. Together, they form a network of causal or consequential relationships.

Using SEM, a combination of factor analysis, path analysis, and multiple regression analysis was employed. structural equation modeling software was used to construct the structural equation model and test and revise the theoretical model. During this process, the impact path of emotional engagement on behavioral engagement was added, non-significant paths (Interactional engagement-behavioral engagement) were removed, and the suboptimal chi-squared P-values due to the large sample size were accounted for. This completed the construction of the final model. Quantitative analysis showed that most model fit indicators met the required standards and exhibited a certain degree of stability, indicating that the revised SPOC learning engagement evaluation model for college students had an acceptable fit.

The results of the phase 2 of the research validated the conceptual soundness and practical feasibility of the engagement evaluation model's assumptions.

With the completion of the final version, the research entered the third phase, which included full-scale classroom implementation and evaluation using a controlled experiment.

Findings Related to Objective 3 –Evaluate the effectiveness of learning engagement in the hybrid teaching model based on the SPOC platform

Sample Overview

To evaluate the effectiveness of learning engagement assessment in supporting SPOC platform instruction, this study employed a controlled experiment and data comparison approach, comparing exam scores and course objective achievement between the experimental and control groups. A total of 71 undergraduate students from the School of Management at Shenyang University of Technology participated in this phase of the study. All participants were cluster sampled from classes 2301 and 2302 of the Marketing major. Real-time teaching and exam data from the Marketing course were collected. Underlying the assumptions were that students had the same major, prerequisite courses, instructors, teaching process, and time schedule, ensuring that external factors did not affect the accurate assessment of learning engagement.

Overview of Controlled Experiments

Participants were divided equally into two groups:

The experimental group (n=36) adopted a dashboard-based teaching intervention designed around an emotional activation, cognitive deepening, and behavioral externalization cycle, with three rounds of process evaluation and instructional adjustment.

The control group (n=35) followed the conventional SPOC blended teaching procedure without additional intervention.

Both groups participated in an eight-week "Marketing" course, covering the same course content with consistent teaching objectives and achievement standards. To ensure the effectiveness of the experiment, the experimental group's teaching process was adjusted as follows:

The experimental group used the SPOC platform's online and offline hybrid teaching model, supported by learning engagement assessment, following a complete four-stage closed-loop teaching process: learning phase ⟶ process evaluation ⟶ summary and feedback ⟶ teaching improvement. Teachers used the second, fourth, and sixth weekly process evaluations as milestones, integrating the collected course learning data into a learning engagement assessment model. Teachers summarized and reflected on the teaching process, provided feedback, and made three adjustments to the course's teaching model, teaching methods, and classroom activities. The final exam scores and achievement of the course's teaching objectives were used to assess the effectiveness of the learning engagement assessment model in guiding instruction.

The control group used the same SPOC platform (online and offline) hybrid teaching model, with no phased teaching process. Process evaluations were conducted simultaneously with the experimental group on the second, fourth, and sixth weekly cycles, but no adjustments were made to the model, methods, or classroom activities after the evaluations. Final exam scores and achievement of the course's teaching objectives were used as control data for comparison with the experimental group to identify gaps.

The same teacher taught both classes, alternating between classes to minimize teaching bias. All courses were conducted online and offline, with strict consistency in time allocation and teaching materials.

Assessment tools and data collection time

To evaluate the impact of learning engagement assessments and interventions, the following procedures were used:

Each process assessment consisted of 15 questions, with a maximum score of 100 points, and the weighting assigned to each course objective was the same. Both

groups used the same assessment content and were scored using a unified grading rubric to ensure consistency.

A final exam, with a maximum score of 100 points, was administered at the end of the eighth week of instruction. The weighting assigned to each course objective was the same. Both groups used the same assessment content and were scored using a unified grading rubric to ensure consistency.

The process assessment and final exam scores were combined to form a comprehensive assessment of course objective achievement, and both groups used a unified grading rubric to ensure consistency.

The process assessment, final exam, and course objective achievement were compared to determine the impact of the learning engagement assessment and interventions.

Course objective achievement is central to course design and a crucial indicator for evaluating teaching quality. By collecting data on the teaching process and outcomes, we quantitatively assess students' mastery of course objectives, providing empirical support for learning engagement assessments and interventions. Descriptive statistics of the process evaluation and final examination scores of the two groups are shown in Table 4.23 below.

Table 4.23 Descriptive statistics of process evaluation and final examination scores

Group	Evaluation Project	Number of samples n	average score M	Standard deviation SD
Experimental Group	Process assessment 1	36	64.28	7.78
	Process assessment 2	36	77.50	8.18
	Process assessment 3	36	85.06	7.24
	Final Exam	36	86.32	7.67
Control Group	Process assessment 1	35	65.51	7.67
	Process assessment 2	35	71.05	8.07
	Process assessment 3	36	76.53	8.97
	Final Exam	35	75.46	8.05

Table 4.23 shows that the first process assessment, which served as a pre-test for the first learning engagement assessment, yielded very similar mean scores and standard deviations for the two groups. This indicates that prior to the learning engagement assessment and intervention, the two groups had comparable knowledge and ability levels.

Of particular note, both groups of students were from the same major and year, had the same pre-test courses, and were exposed to the same learning environment. This design effectively ensured a balanced distribution of learning backgrounds, course exposure, and teaching environment. The use of the same instructor, consistent teaching content, and class schedule further eliminated the influence of potential confounding factors. These conditions not only enhanced the internal validity of the experimental design but also ensured the comparability of the data between the two groups.

Analysis of Table 4.23 shows that as the learning engagement assessment progressed and the intervention results deepened, significant differences in student performance emerged. The experimental group's scores improved significantly, while the control group's gains were less pronounced and fluctuated. Given that the test was identical to the pre-test, ensuring consistency in difficulty, structure, and scoring criteria, the test results clearly demonstrate that the implementation of the learning engagement assessment and its intervention in course instruction have been effective. The statistical results of the two groups of students' achievement of the course teaching objectives are listed in Table 4.24, and the segmented statistical visualization is shown in Figure 4.6.

Table 4.24 Statistics of students' achievement of course teaching objectives

Group	Course Teaching Objectives	Number of samples n	Average achievement M	Segmented statistics N				
				0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1.0
Experimental group	Knowledge Objectives	36	0.850	1	1	6	4	2
	Skill Objectives	36	0.803	1	3	5	4	0
	competency goals	36	0.787	0	1	2	4	2
	Subtotal	36	0.813	2	5	13	12	4
Control group	Knowledge Objectives	35	0.812	3	2	3	5	1
	Skill Objectives	35	0.757	2	3	4	1	0
	competency goals	35	0.762	2	5	3	1	0
	Subtotal	35	0.777	7	10	10	7	1

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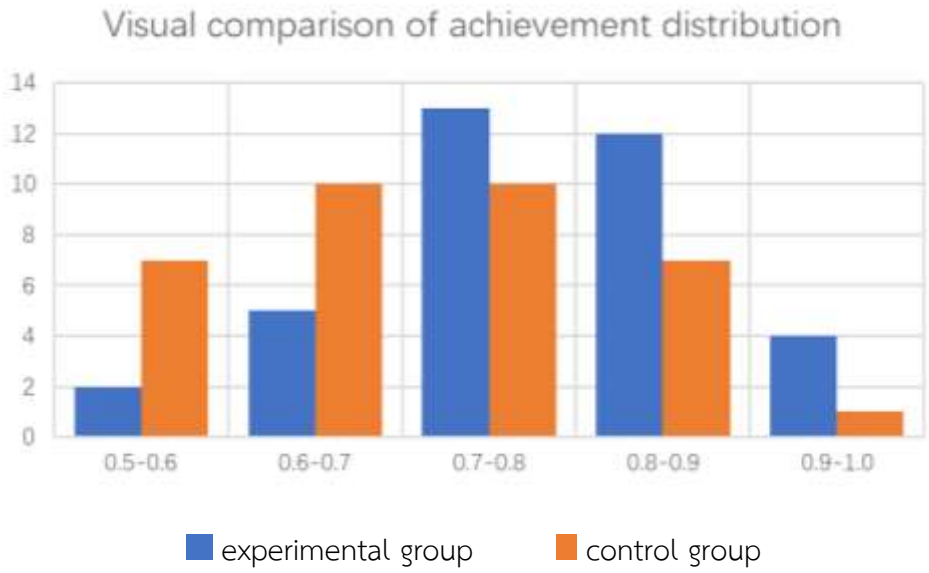

Figure 4.6 Visual comparison of achievement distribution

The results show that students in the experimental group performed significantly better than those in the control group. Considering that the average scores of the two groups were nearly identical before the test, this difference is significant and effective. The significant improvement in the experimental group's performance suggests that the intervention using learning engagement assessments has had a positive impact on student behavior in the SPOC course. The bar chart shows the segmented distribution of teaching achievement scores for the experimental and control groups. It can be observed that the experimental group's achievement scores are more tightly concentrated in the higher range (0.7-0.9), indicating greater stability and stronger overall performance.

In contrast, the control group's score distribution is more dispersed, with several students achieving achievement scores below 0.55, indicating greater variability and a lower average achievement score. This intuitive data supports the previously presented statistical results, confirming that the use of learning

engagement assessments and interventions in the teaching process achieves higher and more consistent teaching outcomes compared to traditional SPOC teaching methods.

Student questionnaires revealed that student learning engagement has a significant positive impact in the following five areas:

1. In terms of impact, all four dimensions showed significant positive effects. Active student engagement in SPOC learning activities is conducive to increased SPOC learning engagement and improved course achievement.

2. Interactional engagement only directly impacts students' emotional and cognitive engagement in SPOC learning, and indirectly influences behavioral engagement as a potential factor. Specifically, individual student Interactionals with teachers, peers, or classmates do not directly affect their adherence to classroom rules, consistent participation in course activities, and quality and quantity in completing learning tasks.

3. Cognitive engagement, as a key factor in learning engagement, directly impacts behavioral engagement and is directly influenced by Interactional and emotional engagement. Specifically, the deeper a student's understanding of the course and its instruction, the higher their learning engagement, directly impacting classroom teaching effectiveness and improved teaching achievement.

4. Emotional engagement directly influences students' attitudes toward learning activities, which in turn influences both behavioral and cognitive engagement. Specifically, when students emotionally identify with the course content and teaching model, they will proactively engage in learning activities, leading to an overall improvement in their learning engagement.

5. Behavioral engagement, the most direct reflection of learning engagement, is influenced by Interactional engagement, cognitive engagement, and emotional engagement, with emotional engagement and Interactional engagement having a greater impact. Specifically, during the course learning process, increased learning engagement is most evident in students' willingness to actively participate in Interactionals with teachers, peers, and classmates.

Chapter 5

Conclusion Discussion and Recommendations

Conclusion

This study was conducted in the context of online and offline blended teaching based on the SPOC digital platform. The Marketing course offered on the SPOC platform by six universities, including Shenyang University of Technology, was selected as the implementation context. Students from relevant majors in these universities were selected as the sample group. The study was completed in three phases. The objectives of this study were as follows:

1. To survey the current state of student learning engagement in blended teaching based on the SPOC digital platform.

2. To develop a model for assessing student learning engagement in blended teaching based on the SPOC digital platform.

3. To evaluate the effectiveness of the developed student learning engagement model for blended teaching based on the SPOC digital platform.

Based on these objectives, the major findings of the study are summarized as follows:

The sample group of this study consisted of 1,080 four-year undergraduate students who participated in online and offline blended teaching based on the SPOC digital platform. In the controlled experiment, a total of 71 students were selected and divided into an experimental group of 36 students and a control group of 35 students. The main research instruments included questionnaires, rating scales, structural equation models, and teaching effectiveness assessment tables. The statistical methods used for data analysis included descriptive statistics, Cronbach's alpha coefficient, confirmatory factor analysis (CFA), composite reliability (CR), average variance extracted (AVE), structural equation modeling (SEM), t-tests, effect size (Cohen's d), and mediation analysis.

Research Summary

Through a review and analysis of the literature, and by drawing on relevant studies on SPOCs and learning engagement at home and abroad, as well as learning engagement theory, student participation theory, flow theory, and educational evaluation theory, a theoretical model for evaluating college students' SPOC learning engagement was constructed. Using structural equation modeling software, the theoretical model was tested and revised. The path relationships and effects among students' behavioral engagement, interactional engagement, cognitive engagement, and emotional engagement were examined and discussed.

The research findings can be summarized in three main aspects: the preliminary construction of a model for evaluating college students' SPOC learning engagement, the verification and revision of the model, and the analysis of the relationship between SPOC learning engagement and teaching effectiveness.

1. Theoretical Model for Evaluating College Students' SPOC Learning Engagement.

By reviewing existing studies and theories related to SPOCs and learning engagement, an applicable model for evaluating college students' SPOC learning engagement was developed. Based on relevant theoretical models, the characteristics of SPOC learning, the demographic characteristics of college students, the structure of learning engagement, and related theories, a preliminary theoretical model for evaluating college students' SPOC learning engagement was constructed. This evaluation model included four evaluation dimensions, namely behavioral engagement, interactional engagement, emotional engagement, and cognitive engagement. Each latent variable contained multiple specific elements or measurement indicators: five indicators for behavioral engagement, three for interactional engagement, three for emotional engagement, and four for cognitive engagement, making a total of 15 measurement indicators.

2. Final Model for Evaluating College Students' SPOC Learning Engagement.

Using structural equation modeling software, 895 valid questionnaires collected during the field test were analyzed. Based on the degree of fit between the observed data and the theoretical model, and in combination with relevant theories, the theoretical model was tested and revised, ultimately resulting in a final model for evaluating college students' SPOC learning engagement. The results showed that interactional engagement had a significant positive effect on college students' emotional engagement and cognitive engagement in SPOC learning, but had no significant direct effect on behavioral engagement. Specifically, the higher the level of interaction with teachers or peers during SPOC learning, the higher the students' interest in the course and the stronger the cognitive and metacognitive strategies they adopted. However, this had little direct effect on their compliance with classroom rules, participation in classroom activities, and the quality of course assignments or learning tasks. Emotional engagement was directly influenced by interactional engagement and also directly affected college students' cognitive engagement and behavioral engagement in SPOC courses. Specifically, the stronger the learners' interest in SPOC learning, the more actively they adopted corresponding learning strategies and measures, which was further reflected in their learning behavior. Cognitive engagement had a significant direct effect on behavioral engagement. The higher the level of learning strategies adopted by college students during SPOC learning, the more likely they were to demonstrate active engagement through their behavior.

3. Relationship between College Students' SPOC Learning Engagement and Teaching Effectiveness.

When calculating the weights of the evaluation indicators at each level, it was found that cognitive engagement accounted for a relatively larger weight, although the weights of the four evaluation dimensions were generally balanced. When analyzing the relationship between learning engagement and teaching effectiveness through a controlled experiment, it was found that students in the experimental

group performed significantly better than those in the control group. Considering that the average scores of the two groups were almost identical before the experiment, this difference can be regarded as significant and meaningful. The significant improvement in the performance of the experimental group indicates that the use of learning engagement assessment to intervene in students' behavior during SPOC courses had a positive effect. Compared with traditional SPOC teaching methods, the model that incorporated learning engagement assessment and intervention into the teaching process achieved better and more stable teaching outcomes.

Through questionnaire interviews with students, it was found that students' learning engagement had a significant positive effect in the following five aspects.

1. From the perspective of effect relationships, the four dimensional variables showed positive and significant relationships. Students' active participation in learning activities in SPOC courses was conducive to improving SPOC learning engagement and enhancing course achievement.

2. Interactional engagement directly affected only college students' emotional engagement and cognitive engagement in SPOC course learning, and indirectly affected behavioral engagement as a potential factor. In other words, the interaction between college students and teachers, learning partners, or classmates did not directly affect their compliance with classroom rules, persistence in participating in course activities, or ability to complete learning tasks in both quality and quantity.

3. Cognitive engagement, as an important factor in learning engagement, not only directly affected behavioral engagement, but was also directly influenced by interactional engagement and emotional engagement. In other words, the deeper the college students' understanding of the course and its teaching process, the higher their learning engagement, which in turn directly promoted the improvement of classroom teaching effectiveness and academic achievement.

4. Emotional engagement directly affected college students' attitudes toward learning activities and further influenced behavioral engagement and cognitive

engagement. In other words, when college students emotionally identified with the course content and teaching model, they became more willing to participate actively in learning activities, leading to an overall improvement in learning engagement.

5. Behavioral engagement, as the most direct manifestation of learning engagement, was influenced by interactional engagement, cognitive engagement, and emotional engagement, among which emotional engagement and interactional engagement had a greater impact. In other words, during the course learning process, the most obvious manifestation of improved learning engagement among college students was their willingness to actively participate in interactions with teachers, learning partners, or classmates.

Discussion and Recommendations

Comprehensive Discussion of the Learning Engagement Model

The model for evaluating college students' learning engagement within the SPOC platform proposed in this study demonstrated a good fit in the statistical tests. The results indicated that the four dimensions—behavioral engagement, cognitive engagement, emotional engagement, and interactional engagement—effectively reflected student engagement in a blended learning environment. Similar to most existing studies, this study confirmed the multidimensional nature of learning engagement, while also revealing certain contextual differences.

Specifically, behavioral engagement and cognitive engagement were relatively prominent, indicating that students were able to maintain learning routines and complete tasks effectively within the SPOC model. Emotional engagement was generally positive but showed some fluctuation, suggesting that emotional factors were easily influenced by the course atmosphere and teaching methods. Interactional engagement, on the other hand, was relatively weak, indicating that teacher-student interaction and peer collaboration remained weak points in blended learning. These findings not only confirmed the general applicability of learning engagement theory, but also suggested that student learning behavior may present distinctive features within the cultural context of Chinese universities.

Student Learning Characteristics

This study further revealed the interaction among different dimensions. Interactional engagement not only directly enhanced emotional experience, but also indirectly promoted cognitive processing and behavioral performance through emotional engagement. This result suggests that student engagement is a dynamic system rather than an isolated variable. For example, when students have positive experiences in group collaboration or online discussion, they are more likely to develop emotional identification and thus become more willing to engage in deeper thinking and practical learning activities. This finding reminds us that learning is not a one-way process of knowledge transmission, but rather a comprehensive process involving the coordinated development of interaction, emotion, and cognition.

Implications for Teaching Practice

The research findings provide targeted recommendations for frontline teaching practice. Teachers should appropriately shift their role in curriculum design from “knowledge transmitters” to “learning facilitators.” While ensuring that students complete their learning tasks, teachers should also promote deeper understanding and cultivate higher-order thinking skills through inquiry-based tasks, scenario simulations, and case studies. Furthermore, the results from the emotional dimension suggest that teachers need to pay attention to students’ psychological experiences in the classroom, for example, by using positive feedback, encouraging comments, and motivating language to stimulate learning enthusiasm. More importantly, the weaknesses found in the interactional dimension require teachers to design more meaningful interaction mechanisms rather than relying only on superficial question-and-answer activities.

Reflections on Schools and Platform Development

At the school and management levels, the results of this study provide a useful reference for optimizing digital platforms. The advantage of the SPOC platform lies in its integration of online and offline learning, but its full value depends on the strength of its interaction functions and learning analytics tools. Schools should incorporate real-time feedback systems, data visualization tools, and peer

collaboration mechanisms into platform development so that teachers can identify student engagement through data and provide timely intervention. Furthermore, learning engagement indicators may become an important component of course evaluation systems, making the assessment of teaching quality more comprehensive. Through institutional design, schools can encourage teachers to pay closer attention to students' multidimensional learning performance rather than relying solely on test scores.

Implications for Policy and Educational Strategy

At a more macro level, the findings of this study suggest that education policymakers should include learning engagement as a core indicator of higher education teaching quality. Traditional quality evaluation tends to focus on outcomes while neglecting process-oriented elements. This study shows that learning engagement can effectively predict student learning outcomes, and therefore incorporating it into quality assessment criteria may help promote teaching reform. Furthermore, in advancing the digital transformation of education, policymakers should avoid emphasizing technology at the expense of teaching, and should instead give priority to teacher training and the renewal of teaching concepts. Finally, resource sharing and inter-university collaboration may help expand interactional space and improve student engagement on a broader scale.

Limitations of the Study

It should be noted that although this study achieved certain results, it still has some limitations. First, the sample was limited to a small number of universities in Liaoning Province, which may restrict the generalizability of the findings. Second, the research participants were marketing students, and the applicability of the model to other disciplinary contexts still needs to be verified. Third, the research data mainly consisted of questionnaires and short-term experiments, lacking long-term follow-up and therefore failing to reveal the dynamic evolution of learning engagement. Finally, this study lacked an in-depth analysis of cultural and psychological mechanisms, and therefore did not fully explain the relatively low level of interactional engagement, which remains an issue for further exploration.

Future Research

Based on the literature analysis, a theoretical model for evaluating learning engagement in online and offline blended teaching based on the SPOC digital platform was initially constructed. The theoretical model was tested and revised in combination with relevant theories and actual survey data, resulting in the final evaluation model. The relationship between the model and teaching effectiveness was also examined and discussed. Although the research results demonstrated the effectiveness of the model and its practical value in education and teaching, the study still has certain limitations in terms of sample size, research scope, and intervention duration. Therefore, future research should further expand, refine, and promote the model in order to improve it continuously.

1. College students' SPOC learning engagement needs to be examined comprehensively from multiple perspectives. In this study, the evaluation indicators and dimensions of learning engagement were explored mainly from the perspective of students themselves, while the influence of many external factors, such as schools, educators, and the environment, was not considered. In future research, the scope may be expanded to further explore the influence of external factors such as society, school, family, and teachers on college students' SPOC learning engagement, so as to make the evaluation more comprehensive and systematic.

2. Future research on SPOC learning engagement should consider expanding the scope of implementation. The research samples in this study were mainly drawn from two cities in Liaoning Province in Northeast China, involving six universities and a total of 1,080 students, of whom 71 participated in the controlled experiment. Although stratified sampling ensured a balance across different schools, majors, and academic years, expanding the study to multiple countries and universities with different cultural and institutional contexts would provide greater generalizability. Cross-national or cross-regional comparative studies could also highlight how cultural differences in communication patterns affect the effectiveness of SPOC learning engagement evaluation in supporting teaching models.

3. Future research on SPOC learning engagement may use long-term longitudinal data collection and monitoring to capture the long-term impact of learning engagement on teaching effectiveness. The current intervention was based on the eight-week implementation of the Marketing course. Although this duration was sufficient to meet the requirements for measuring the learning outcomes of a single course, it could not assess long-term memory, skill transfer, sustained learning motivation, or the influence between preceding and subsequent courses. Long-term research may further examine whether students continue to maintain learning engagement in subsequent courses and skill training, as well as the impact of learning engagement intervention on the teaching effectiveness of different types of courses. Such research would further enhance the applicability of the evaluation model in different teaching modes.

4. In future research on SPOC learning engagement, researchers should further increase the integration of artificial intelligence. For example, AI-driven big data feedback systems, audio and video capture technology for classroom data collection, facial expression recognition technology, and emerging technologies such as virtual reality or augmented reality may all be incorporated to create a more representative and adaptable evaluation model structure. Future studies may also test the combination of learning engagement evaluation with other teaching modes, such as the flipped classroom, group task-based teaching, and case-based teaching, rather than limiting the research to blended learning only, so as to further enhance the versatility of the model and its support for the teaching effectiveness of various courses.

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Appendices

Appendix A

List of Specialists and Letters of Specialists Invitation for IOC Verification

Name of Experts	Position
Su Xiaoming	Dean of Academic Affairs of Shenyang University of Technology
Li Yi	Doctoral supervisor of the School of Management Shenyang University of Technology
Lin Yanxin	Associate Professor of School of Economics and Management, Shenyang University of Chemical Technology
Gong Hua	Dean of Academic Affairs of Shenyang University of Technology
An Qun	Vice President of Liaoyang Vocational and Technical College of Architecture

Appendix B

Official Letter

Ref.No. MHESI 0643.14/

Bansomdejchaopraya
Rajabhat University
1061 Itsaraparb Hirunrujee
Thonburi Bangkok 10600

11 October 2024

Subject: Invitation to validate research instrument

Dear

Mrs. Song Linfei is a graduate student in doctor of Digital Technology Management for Education of Bansomdejchaopraya Rajabhat University. She is undertaking research entitled "Development of a Student Learning Engagement Model for Blended Teaching Models Based on Small Private Online Course Digital Platforms". There is a thesis advisory committee as follows:

Assistant Professor Dr. Prapai Sridama

Assoc Professor Dr. Sombat Teekasap

Assistant Professor Dr. Kanakorn Sawangcharoen

The thesis advisory committee has considered that you are an expert in this topic. Your recommendations would be useful for further improvement of this research instrument.

With your expertise, we would like to ask your permission to validate the attached research instrument. In this regard, we would like to avail ourselves of this opportunity to express our sincere thanks and appreciation for your help.

Yours faithfully,

Assistant Professor Dr.Thanaput Chancharoen
(Vice Dean of Graduate School for Dean of Graduate School)
Graduate School
Tel.+662-473-7000 ext. 1814
E-mail: grad@bsru.ac.th

Appendix C

Research Instrument

Questionnaire on College Students' SPOC Learning Engagement

Hello, this is a questionnaire regarding the learning engagement of undergraduate students using SPOC. This questionnaire is anonymous; there are no right or wrong answers. All information will be used solely for academic research and is strictly confidential. Please answer truthfully, thank you!

Instructions: SPOC refers to a small-scale, restricted online course used in combination with offline classroom teaching. Learners are usually limited to students from the same class, the same school, different schools but the same major, or a specific region (e.g., a university town).

I. Multiple Choice Questions: Determine the degree to which the descriptions in the options match your own situation.

	Strongly disagree	disagree	neutral	agree	strongly agree
BE1. I follow the rules of the SPOC class.	1	2	3	4	5
BE2. Before completing or submitting, I check the SPOC coursework for knowledge point errors.	1	2	3	4	5
BE3. I feel like the SPOC coursework I submitted is of good quality.	1	2	3	4	5
BE4. I don't give up halfway when it comes to completing SPOC's learning tasks.	1	2	3	4	5
BE5. Whenever there is a learning task assigned in the SPOC course, I always actively cooperate with it.	1	2	3	4	5

	Strongly disagree	disagree	neutral	agree	strongly agree
IE1. This kind of SPOC classroom is fun.	1	2	3	4	5
IE2. When we discuss an issue in a SPOC class, I find it interesting.	1	2	3	4	5
IE3. Enjoy some of the fun activities in the SPOC course.	1	2	3	4	5
EE1. I often take the initiative to chat and discuss SPOC courses with teachers or other classmates online.	1	2	3	4	5
EE2. I often take the initiative to communicate with teachers online about the content of SPOC courses.	1	2	3	4	5
EE3. I often take the initiative to help students who encounter difficulties in SPOC courses online.	1	2	3	4	5
CE1. Applying SPOC course content to my life.	1	2	3	4	5
CE2. Finding ways to connect the SPOC course content to my life.	1	2	3	4	5
CE3. In the SPOC course, if what I am learning is difficult to understand, I will change my learning style, thinking, or strategy.	1	2	3	4	5
CE4. I have my own study plan and intention regarding this SPOC course.	1	2	3	4	5

II. Basic Information

1. Your school?
2. Your major?
3. Your gender: ○Male ○Female
4. Your year of study: ○Freshman ○Sophomore ○Junior ○Senior ○Fifth Year
5. Your class ranking in the first semester of last year (during the pandemic)?
6. Total number of students in your class?

Thank you for your participation and support. Have a wonderful day!

Appendix D

The Results of the Quality Analysis of Research Instruments

Class
Student ID
Name

Shenyang University of Technology

Exam Title: Marketing

I. Multiple Choice (2 points each, 20 points in total)

1. The hallmark of the "revolution" in marketing is the introduction of the concept of _____.

A. Consumer-centric B. Producer-centric
C. Marketing mix D. Internet marketing

2. The common means by which enterprises perceive the external world is _____.

A. Public relations B. Marketing
C. Listening D. Market research

3. The domestic market can be divided into consumer market, producer market, intermediary market, and non-profit organization market according to _____.

A. Purchase motive B. Product use
C. Purchase psychology D. Demographic factors

4. The main body of public relations activities is _____.

A. A certain organization B. Customers
C. Government officials D. Salespeople

5. When the differences between different brands of similar products are small, consumer purchasing behavior is _____.

A. Simple B. Complex
C. General D. Difficult

6. Service is an intangible product; it provides customers with the product's _____, without involving the transfer of ownership.

A. Management rights B. Protection rights
C. Ownership D. Right of Use

7. Using scientific methods to purposefully and systematically collect, organize, and analyze information related to marketing, and to propose solutions to problems, providing marketing managers with insights into the marketing environment, opportunities, and issues, and serving as the basis for market forecasting and marketing decisions, we call this _____.

A. Marketing Information System
B. Market Research
C. Market Forecasting
D. Decision Support System

8. The greatest advantage of adopting an undifferentiated marketing strategy is _____.

A. High market share
B. Cost economy
C. Strong market adaptability
D. High degree of demand satisfaction

9. Companies that have the ability to take offensive action against market leaders and are expected to seize the position of market leaders belong to _____.

A. Strong competitors B. Market challengers
C. Market niche D. Good competitor

10. The registered brand is conducive to protecting the legitimate rights and interests of the _____.

A. Owner of goods B. Owner of assets
C. Brand owner D. Product owner

II. Multiple choice (3 points for each question, 15 points in total)

1. The core of marketing management philosophy is to correctly handle the interests between _____.

A. Enterprise B. Supplier
C. Customer D. Middleman
E. Society

2. According to whether consumers belong to the group members and the attractiveness of the group, the relevant groups can be divided into _____.

A. Positive related member groups B. Yearning groups
C. Rejection group D. Quarantine group
E. Social groups

3. Which of the following benefits does market segmentation have for enterprise marketing_____?

A. It is conducive to discovering market opportunities B. It is conducive to grasping the characteristics of the target market
C. It is conducive to formulating marketing mix strategies D. It is conducive to improving the competitiveness of enterprises
E. It is conducive to saving costs

4. New product development needs to optimize the best product concept, and the basis of selection is _____ and the full use of enterprise equipment and resources.

A. Technical capabilities B. Future market potential capacity
C. Return on investment D. Production capacity

Class
Student ID
Name

Shenyang University of Technology

E. Sales growth rate

3. The alternating scheme of channels mainly involves _____:

A. Middleman type　　B. Customer preferences

C. Product nature　　D. Number of intermediaries

E. Specific tasks of channel members

III. True or False (1 point for each sub-question. 10 points in total)

1. The development of the market is a dynamic process determined by the consumer buyer and driven by the producer and seller;

2. Business strategy is the strategy of multiple strategic business units or related professional departments and subsidiaries;

3. The marketing goal is subordinate to the overall goal of the enterprise and is a secondary goal that serves the overall goal.

4. Usually, bowling alleys do not promote bowling to the frugal group;

5. In the process of information transmission through interpersonal channels, the information received by the receiver may be very different from the information sent by the information source, that is, the information transmission is distorted;

6. Market specialization is the simplest target market model;

7. The selection of challenge strategies should follow the principle of "guerrilla attack";

8. The value of brand assets ultimately depends on the quality of the company's products;

9. Product differentiation makes buyers less sensitive to the existence of price differences; Therefore, in the heterogeneous product market, enterprises have greater freedom to determine their prices;

10. The emergence of new stores is to meet the different preferences of customers for service levels and specific service items;

IV. Fill-in-the-blank questions (2 points per blank. 10 points in total)

1. The core of marketing management philosophy is to correctly handle the interest relationship between enterprises, customers and _____;

2. The basis for distinguishing strategic business units is whether there is a common _____ between multiple businesses;

3. The market is composed of _____ who have the desire to buy and the ability to pay;

4. Consumers obtain the most information through commercial sources, followed by public sources and _____, and finally experience sources.

5. In the competitive market, countless marketing activity participants alternately appear as buyers and sellers, who are both publishers of information and _____ of information;

V. Noun explanation questions (3 points for each sub-question. 15 points in total):

1. The public
2. Non-profit organizations
3. Extended products
4. Logistics
5. Customer transfer value

VI. short answer questions (5 points per sub-question. 30 points in total):

1. What role should marketers play in a quality-oriented enterprise?

2. What are the basic steps usually included in marketing research?

3. What supporting documents must be submitted for enterprises to apply for recognition of well-known trademarks;

4. What content is usually included in the marketing plan?

Appendix E

Certificate of English


BS RU BANSOMDEJCHAOPRAYA RAJABHAT UNIVERSITY
This is to certify that
Song Linfei
Achieved BSRU English Proficiency Test (BSRU-TEP) level
C1
Given on 14th September 2024
(Assistant Professor Dr Kulsirin Aphiratvoradej)
Director

Appendix F

The Document for Acceptance Research

วารสารคุณภาพชีวิตกับกฎหมาย
Quality of Life and Law Journal

วันที่ 23 กุมภาพันธ์ 2569

เรื่อง รับรองการพิจารณาบทความวิจัย

เรียน Song Linfei, Asst. Prof. Dr. Prapai Sridama, Assoc. Prof. Dr. Sombat Teekasap, and Asst. Prof. Dr. Kanakorn Sawangcharoen

ตามที่ท่านได้ส่งบทความวิจัย เรื่อง **A Study on the Evaluation of College Students' SPOC Learning Engagement Based on Structural Equation Modeling – Taking the Course "Marketing" as an Example** เพื่อตีพิมพ์ในวารสารคุณภาพชีวิตกับกฎหมายนั้น

บทความของท่านได้ผ่านการประเมินพิจารณาจาก Peer review เป็นที่เรียบร้อยแล้ว และดำเนินการตีพิมพ์ในวารสารคุณภาพชีวิตกับกฎหมาย **ปีที่ 22 ฉบับที่ 1 (มกราคม - มิถุนายน 2569)**

ทั้งนี้ วารสารคุณภาพชีวิตและกฎหมาย ได้ผ่านการประเมินคุณภาพจากศูนย์ดัชนีการอ้างอิงวารสารไทย (Thai-Journal Citation Index : TCI) โดยได้รับการจัดอยู่ในกลุ่มวารสารกลุ่มที่ 2 ไปจนถึงวันที่ 31 ธันวาคม 2572

จึงเรียนมาเพื่อทราบ

(ดร.วรานิษฐ์ ลำใย)
บรรณาธิการวารสารคุณภาพชีวิตกับกฎหมาย

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Chemical Engineering and Technology

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2022. 8 - Present

Ph.D. candidate in Digital Technology Management of Education

Work experience:

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2015.10-2017.6

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Shenyang University of Technology

2017.9 - 2019.3

Assistant Counselor

Liaoshen Bank

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Financial Manager

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