

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

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Abstract

The objectives of this study were: 1) to study the characteristics and elements of student learning engagement patterns under the blended learning model based on the SPOC digital platform; 2) to construct an evaluation model suitable for SPOC learning engagement; and 3) to evaluate the effectiveness of the SPOC learning engagement evaluation model in assisting the achievement of teaching effects. The study population consisted of 209,000 undergraduate students majoring in marketing nationwide. To ensure accuracy, the estimated percentage in the population was magnified by 10%, and a stratified sampling method was used to select 1,080 students as the sample group for the scale. To ensure the scale's effectiveness, five interviewees were selected as interview experts, required to be engaged in university education and teaching management, and to have at least 10 years of teaching experience in business administration-related majors, including teaching research and teaching reform.

Data analysis indicates that the SPOC learning engagement SEM evaluation model comprises four dimensions and 15 elements: behavioral, interactive, emotional, and cognitive engagement. By intervening in the teaching process, the model effectively supports the achievement of teaching objectives.

It is recommended that future research extend the application of this evaluation model to other course types and educational levels, and that instructors use its behavioral, interactive, emotional, and cognitive engagement dimensions as actionable indicators for early intervention in blended SPOC teaching.

Keywords: marketing / SPOC learning engagement / structural equation modeling

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Introduction

With the rapid rise of online education, SPOCs (Small Private Online Courses) have been widely adopted in university classrooms due to their unique ability to overcome time and space limitations. Research on evaluating university students' engagement in SPOC learning is also continuously advancing. The analysis of learners' online learning engagement has inevitably shifted from traditional self-reporting to information collection focusing on the learning process. However, educators' analysis of interactive behaviors during the learning process and the establishment of evaluation models have lagged. The deconstruction and analysis of learning behavior data are crucial areas that urgently need breakthroughs in current research.

To address the above issues, this study selected the "Marketing" SPOC course from six universities, including Shenyang University of Technology, and analyzed its blended online and offline teaching process. First, it reviews the dimensional structure of learning engagement and interactive behaviors, the measurement tools used to assess them, and their impact on learning outcomes. Based on a clear data model and its structural relationships, the correlation between learning engagement and learning outcomes is analyzed. By assigning appropriate weights to each evaluation indicator, the final scores for university students' learning engagement in each structural dimension and assignment are calculated, further validating its effectiveness in assessing learning outcomes.

Problem Statement

1. What are the characteristics and influencing factors of SPOC learning engagement?
2. How to construct an evaluation model and metric for SPOC learning engagement?
3. How to determine the effectiveness of the evaluation model in assisting learning outcomes?

Objectives

1. To study the dimensional structure and constituent elements of SPOC learning engagement.
2. To construct a structural equation model for evaluating SPOC learning engagement.
3. To assess the effectiveness of this model in assisting learning outcomes.

Literature Review

1. Learning Engagement

In the early days, the definition of learning engagement was the time students spent on learning (Axelson & Flick, 2011). Fred M. Newmann (1992) believed that learning engagement is the psychological investment and effort students put into their studies, and that investment is an element used to describe the intrinsic qualities of focus and effort. Schaufeli et al. (2002) defined learning engagement as a positive, satisfying, and learning-related mental state. Wu and Zhang (2018) defined learning engagement as the flexibility, energy, and positive emotions an individual exhibits during the learning process. Gunuc and Kuzu (2015) define learning engagement as the quality and quantity of students' psychological, cognitive, emotional, and behavioral input during the learning process and in-class or out-of-class academic and social activities. This study draws on the above definition and believes that learning engagement in the online-offline blended learning model of the SPOC digital platform can be defined as the quality and quantity of students' psychological, cognitive, emotional, and behavioral input during small-scale, restricted online-offline blended course learning and in-class or out-of-class academic and social activities.

2. Dimensional Structure of Learning Engagement Evaluation Model

Psychological, cognitive, emotional, and other internal mental states are difficult to quantify or evaluate, so they must be assessed through external behavioral indicators. Kong (2000) believes that it should be considered from three dimensions: behavioral engagement, affective engagement, and cognitive engagement. Yin and Xu (2017) deconstructed four dimensions of behavior, emotion, cognition, and social interaction from the special ecological perspective of the interaction between the learning subject, the learning community, and the environment. They explained the relationships among the dimensions. It is the dimension structure with the highest general acceptance at present.

3. Evaluation Tools for Learning Engagement Evaluation Model

Currently, the evaluation tools widely used in SPOC learning engagement evaluation models include classic scales such as NSSE, SEDE, UWES-S, and OSE (Dixson, 2010). This study constructs a structural equation model (SEM) of SPOC learning engagement across four dimensions: behavior, emotion, cognition, and social interaction. Within this framework, a modified OSE scale, using a Likert paradigm, is used as an evaluation tool to assess learning engagement.

4. The effectiveness of learning engagement in achieving teaching outcomes

Learning engagement is closely related to the assessment and improvement of educational quality. Kong Deli (2019) found that in the blended teaching model for SPOC, the overall learning behavior engagement was significantly correlated with the learning effect. Duncan et al. (2012) concluded that synchronous participation in the course (a combination of quality and quantity) had twice the impact on the final exam and overall course grades as asynchronous course participation, and both had a positive impact on learning performance.

Conceptual Framework

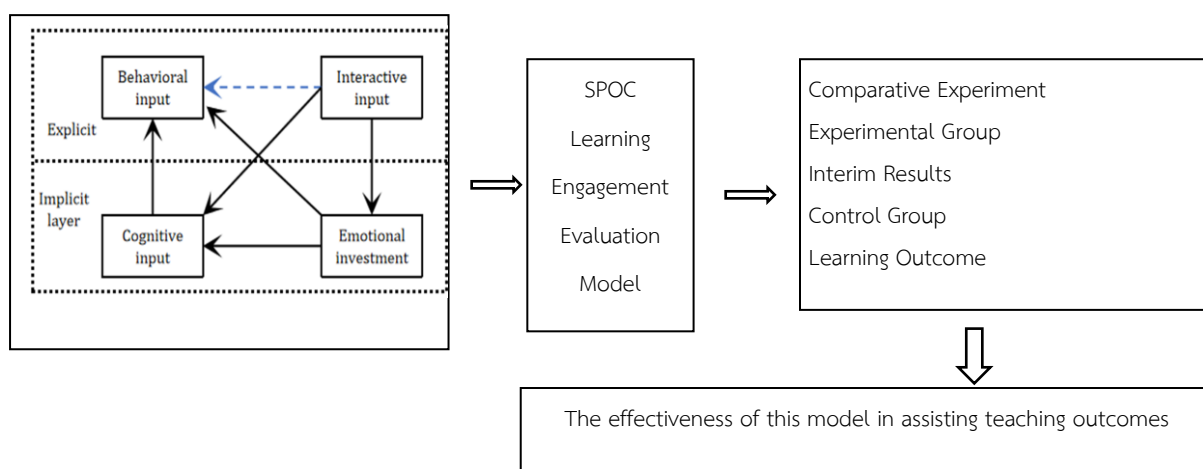


Figure 1: Conceptual Framework

Materials and methods

1. Population/Sample Group

1.1 Population

The sample consists of undergraduate students majoring in Marketing within the Business Administration category in China. According to the "Report on the Development of Marketing Disciplines in Chinese Universities (2024)," 754 universities nationwide offer undergraduate programs in Marketing, with approximately 209,000 undergraduate students.

1.2 Sample Group

Based on Taro Yamane's sample size formula $n = N / (1 + N \cdot e^2)$, where $N = 209,000$ (population size) and $e = 0.05$ (margin of error at 95% confidence level), the minimum required sample size was calculated as $n = 209,000 / (1 + 209,000 \times 0.05^2) \approx 400$ samples. However, applying Cochran's formula for large populations $n = Z^2 \cdot p \cdot q / e^2$, where $Z = 1.96$, $p = 0.5$, $q = 0.5$, and $e = 0.05$, the required sample size is $n = (1.96)^2(0.5)(0.5) / (0.05)^2 = 384$ samples. Adjusting for

a 10% non-response rate, the minimum adequate sample size is 422. To further ensure representation across six universities and four academic years, stratified sampling yielded a target of 516 valid samples from the population. Due to the large population size, to ensure accuracy, the estimated percentage in the population is increased by 10%, and the sample group is increased to 1080 students, using stratified sampling. The sample includes 124 students from Shenyang University of Technology, 117 students from Shenyang University of Chemical Technology, 242 students from Shenyang University of Technology, 129 students from Liaoyang Branch of Shenyang University of Technology, 245 students from Liaoyang Construction Vocational and Technical College, and 223 students from Liaoyang Technician College. 655 students are from provincial capital cities, and 425 students are from non-provincial capital cities. There are 289 first-year students, 272 second-year students, 268 third-year students, and 251 fourth-year students.

2. Interviewees

To ensure the questionnaire's validity, this study selected respondents who were engaged in university education and teaching management, had teaching research and teaching reform experience in business administration-related majors, had at least 10 years of frontline teaching experience in business administration-related majors, and were professors or doctoral degree holders. The selection of five expert respondents was guided by the principle of theoretical saturation (Lincoln & Guba, 1985), which posits that data collection continues until no new themes or information emerge from additional participants. In qualitative expert validation studies, prior research consistently demonstrates that three to seven subject-matter experts are sufficient to reach content saturation (Guest et al., 2006; Fusch & Ness, 2015). Accordingly, five experts were deemed adequate when their combined evaluations yielded consistent Item-Objective Congruence (IOC) scores, confirming that no substantively new insights emerged. A total of 5 respondents were selected.

3. Research Procedures and Steps

This study consists of five steps:

Step 1: Designing the Research Plan

This step involves summarizing domestic and international research literature to understand the current status of online-offline blended teaching models based on SPOC digital platforms, identifying the difficulties and pain points in researching university students' learning engagement under this model, and studying the effectiveness of learning engagement evaluation

and its contribution to achieving teaching goals. Based on this, the research plan for this study is formulated.

The research plan involves surveying university students majoring in marketing-related fields at six universities to examine their engagement and achievement in the SPOC course "Marketing". Literature analysis is used to determine the dimensional structure and the elements of the evaluation model. Expert interviews are then conducted to determine the effectiveness of the model's dimensional elements. A student questionnaire is designed and used to collect survey data and analyze the current status of university students' SPOC learning engagement and achievement. Finally, the evaluation model is determined to promote further the engagement and effectiveness of university students' SPOC learning.

Step 2: Questionnaire Development

Based on the literature review and summarization, the dimensional structure and element composition of the model were preliminarily determined, and a corresponding interview questionnaire (Questionnaire 1) was developed. This questionnaire was submitted to the aforementioned five experts for scoring. The experts evaluated the validity of the model's dimensions and elements, as well as the feasibility of using them to create data scales. They reached a consensus: Item-Objective Congruence (IOC) = 0.92. Based on the interview questionnaire, a SPOC learning engagement evaluation data scale for students was developed.

Step 3: Scale Development and Distribution

The corresponding data scales were also submitted to the aforementioned five experts for review. The experts evaluated the accuracy of each scale and its fit with the model's dimensions and elements, and reached a consensus: Item-Objective Congruence (IOC) = 0.89. After revising the scales based on the experts' feedback, the scales were distributed to the student sample for the survey and statistical analysis, completing the data analysis and reliability and validity verification.

Step 4: Data Analysis

Analyze the data collected from the evaluation scale, calculate extreme values, mean, and standard deviation, and perform Cronbach's α coefficient, combined reliability (CR) value, and average variance extracted (AVE) reliability analysis, as well as confirmatory factor analysis (CFA) validity testing.

Step 5: Model Determination

Based on the analysis results and the literature, determine the student learning engagement evaluation model for the SPOC digital platform blended learning model.

Results

1. Dimensional Structure and Element Composition

Based on literature review and interviews with experts in teaching and research within this field, four dimensions of the model were initially identified: behavioral input, interactive input, affective input, and cognitive input. Evaluation elements were determined for each dimension: behavioral input (performance, diligence, focus, participation, and perseverance); interactive input (collaborative learning, teacher-student interaction, and student-student interaction); affective input (sense of belonging, self-efficacy, and self-worth); and cognitive input (learning strategies, metacognition, resource management, and self-regulation). Using expert questionnaires and interviews, the goal consistency index reached 0.92, indicating that the dimensional structure and element composition are complete and appropriate, and that the instrument is effective in evaluating SPOC learning engagement. Based on the above four dimensions and 15 elements, a student survey questionnaire was designed and produced using a 7-point Likert rating scale. The aforementioned five experts also reviewed this questionnaire, and the goal consistency index was 0.89, indicating that it fits the evaluation model's dimensions and element indicators and is suitable for the evaluation process.

2. Model Construction

Student Survey Sample Distribution

Based on the above 4 dimensions and 15 elements, the student survey questionnaire was distributed to 1080 undergraduate students from all 4 grades of relevant majors in 6 schools. The 1,080 students were drawn from six universities in Liaoning Province: Shenyang University of Technology (117, 10.83%; main campus 242, 22.41%), Liaoyang Branch of Shenyang University of Technology (129, 11.94%), Liaoyang Construction Vocational and Technical College (245, 22.69%), and Liaoyang Technician College (223, 20.65%), giving a balanced cross-institutional sample. By academic year, the sample was evenly distributed: first-year 289 (26.76%), second-year 272 (25.19%), third-year 268 (24.81%), and fourth-year 251 (23.24%), totaling 1,080 students.

The sample was evenly distributed across the four academic years and relatively balanced among the six schools. This balance helps improve the reliability of the analysis, ensuring that

the questionnaire feedback reflects the views and average educational level of all students and avoids bias in interpreting the current state of the SPOC teaching model among schools at different levels.

Analysis of Student Survey Results 1080 questionnaires were collected, a 100% response rate. After removing questionnaires with obvious random responses, contradictions, or identical responses for all respondents, 895 questionnaires were ultimately valid, yielding an 82.59% effectiveness rate. It should be noted that the discrepancy between the initial sample size of 1,080 and the final analytical sample of 895 is attributable to the data-cleaning process: questionnaires exhibiting clear response patterns indicative of random answering (e.g., all identical responses), internal contradictions, or non-serious engagement were excluded to safeguard data integrity. The 895 valid responses, therefore, constitute the cleaned dataset used for all subsequent statistical analyses, including the descriptive statistics reported in

Descriptive statistics of the 895 valid responses (7-point Likert, all items ranging 1–7) showed behavioral input had the highest mean ($M = 5.056$, $SD = 1.315$), followed by emotional investment ($M = 4.703$, $SD = 1.325$) and cognitive investment ($M = 4.658$, $SD = 1.297$), while interactive input was lowest ($M = 4.350$, $SD = 1.425$). Emotional and cognitive input were close in value, and overall, the distribution across dimensions was relatively balanced.

Statistical analysis of the questionnaire's latent variables revealed that the mean for behavioral input was relatively high ($M=5.056$, $SD=1.315$), while the mean for interactive input was relatively low ($M=4.350$, $SD=1.425$). The mean values of emotional and cognitive input were not significantly different, yet their overall distributions were relatively balanced.

Table 1: Reliability Analysis Results of Each Dimension of the Questionnaire

Latent variables	Question Items	UNS TD	S.E.	C.R.	P	STD.	SMC	1-SMC	CR	AVE	Cronbach's α
Behavioral input	BE1	1.000				0.719	0.517	0.483	0.873	0.580	0.871
	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			
Interactive input	IE1	1.000				0.894	0.799	0.201	0.899	0.748	0.898
	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 investment	EE1	1.000				0.878	0.771	0.229	0.895	0.739	0.894
	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 Investment	CE1	1.000				0.873	0.762	0.238	0.908	0.713	0.907
	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			

Table 1 shows the results of the questionnaire reliability analysis. The Cronbach's α coefficients for each latent variable in the developed evaluation tool ranged from 0.871 to 0.907; the CR values ranged from 0.873 to 0.908; and the variance extracted (AVE) ranged from 0.580 to 0.748, all meeting the standard requirements, indicating that the measurement questionnaire had good reliability.

The results of the questionnaire validity test. The square root of the average variance of each latent variable in the evaluation tool is greater than the value on the non-diagonal line of the same row and column, indicating that the evaluation tool has good discriminant validity. Based on the above results, a structural equation model fit test was conducted. Valid questionnaire data were imported into AMOS 24.0, and structural equation modeling was performed to obtain the model fit index test value. This was used to determine whether the structural model fit index met the fit criteria, thus illustrating the model's fit and its applicability for evaluation.

This study employed three verification methods: standardized factor-loading tests for each model variable, variance and significance tests for exogenous variables, and unstandardized regression coefficient and significance tests. After continuous iteration and correction of the model, the final results showed that: the factor loading coefficients of the indicator variables were all between 0.50 and 0.95; the error variances were all positive; the error variation parameter (C.R.) was greater than 1.96, all reaching a significant level; and the absolute values of the correlation coefficients among all variables were less than 0.887, not too close to 1. In summary, the model's intrinsic quality is essentially ideal. The correlation coefficient matrix among the model variables confirmed adequate internal quality: all standardized factor loadings fell between 0.50 and 0.95, all error variances were positive, all critical ratios (C.R.) exceeded 1.96 (significant), and the absolute values of the inter-variable correlations remained below 0.887, i.e., not so close to 1 as to indicate multicollinearity. At the latent-variable level, the four dimensions were strongly and positively intercorrelated (e.g., behavioral–emotional $r = 0.831$; interactive–

emotional $r = 0.822$; behavioral–interactive $r = 0.779$). Cognitive input showed comparatively lower associations, $r = 0.631$ – 0.724 .

The revised model can be used to comprehensively evaluate and assess college students' learning engagement in SPOC. The theoretical model for evaluating students' learning engagement in the online and offline blended teaching model based on the SPOC platform has been largely verified. The final evaluation model for college students' learning engagement in SPOC is shown in Figure 2.

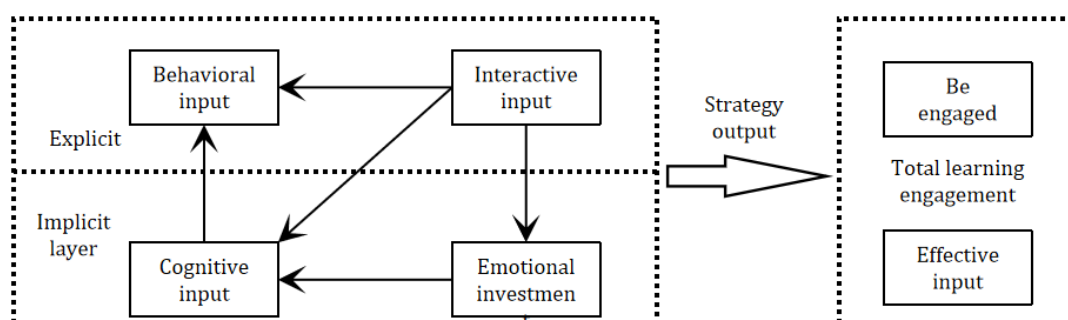


Figure 2. Evaluation model of learning engagement in an online-offline blended learning model based on the SPOC platform.

3 Empirical Analysis

To evaluate the auxiliary effect of learning engagement assessment on SPOC platform teaching, this study employed a controlled experimental design, validating the study by comparing exam scores and course objective achievement rates between the experimental and control groups. Seventy undergraduate students from the School of Management at Shenyang University of Technology participated in this phase of the study. All participants were selected using cluster sampling, from Marketing majors Class 2301 (experimental group, using a blended online and offline teaching model supported by the learning engagement assessment SPOC platform, $n=35$) and Class 2302 (control group, using a traditional SPOC platform teaching model, $n=35$). Teaching and exam data for the "Marketing" course were collected in real time. The descriptive statistics of the assessment scores for the two groups and the statistical results for course objective achievement are reported below, and Figure 4 presents a visual comparison of the achievement rates for the course teaching objectives.

Descriptive statistics for the process and final-exam scores ($n = 35$ per group) showed that the experimental group improved steadily across the three process assessments ($M = 64.28, 77.50, 85.06$) and reached a final-exam mean of 86.32 ($SD = 7.67$). In contrast, the control group rose

more modestly ($M = 65.51, 71.05, 76.53$) to a final-exam mean of 75.46 ($SD = 8.05$) an advantage of roughly 11 points for the experimental group.

Course-objective achievement was higher and more consistent in the experimental group, whose overall mean achievement rate was 0.813 (knowledge 0.850, skill 0.803, competency 0.787), compared with 0.777 for the control group (knowledge 0.812, skill 0.757, competency 0.762). The experimental group also concentrated more students in the upper achievement bands (0.8–1.0), indicating a more equitable distribution of learning outcomes.

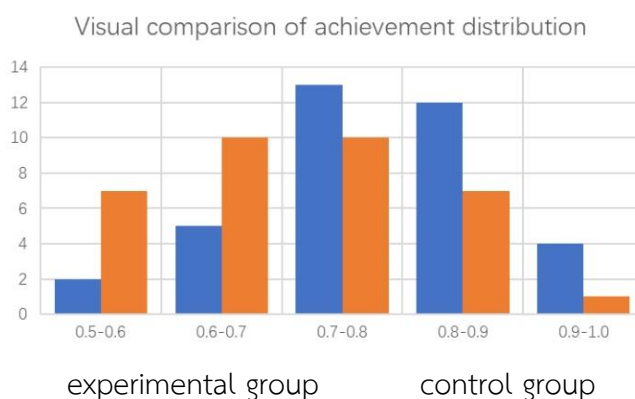


Figure 4. Visual comparison of achievement distribution

Discussion and Conclusions

The four-dimensional structure confirmed by the SEM evaluation model—behavioral, interactive, emotional, and cognitive engagement—is consistent with Yin and Xu’s (2017) deconstruction of learning engagement into behavior, emotion, cognition, and social interaction, the dimensional structure with the highest general acceptance in the field, and extends Kong’s (2000) earlier three-dimensional model by empirically validating interactive engagement as a distinct, separable dimension within the SPOC blended-learning context. The finding that emotional and interactive engagement function as comparatively underexamined “implicit layers” affecting learning outcomes also aligns with Schaufeli et al.’s (2002) conceptualization of engagement as a positive, satisfying, learning-related mental state, and with Gunuc and Kuzu’s (2015) view of engagement as a joint psychological, cognitive, emotional, and behavioral investment, suggesting that purely behavioral indicators are insufficient to capture the full construct.

The comparative experiment results, in which the experimental group achieved higher and more consistent process and final-exam scores alongside higher course-objective

achievement rates, corroborate Kong Deli's (2019) finding that overall learning behavior engagement is significantly correlated with learning effect in SPOC blended teaching, and are consistent with Duncan et al.'s (2012) conclusion that structured course participation has a measurable positive impact on final examination and overall course performance. Taken together, these results support the practical value of using a multidimensional, theory-grounded engagement evaluation model—rather than relying on a single behavioral proxy—to identify at-risk students and guide targeted instructional intervention in blended SPOC courses.

From a quality-of-life (QoL) perspective, these findings carry implications that extend beyond academic performance. Because emotional and interactive engagement emerged as influential yet often-overlooked “implicit layers,” an evaluation model that makes these dimensions visible allows instructors to detect and respond to the frustration, isolation, and disengagement that can undermine students' psychological well-being in online and blended environments. By enabling earlier, more targeted intervention for at-risk students, the model helps reduce the cumulative academic stress and sense of falling behind that are known to erode students' mental health and life satisfaction. In this sense, an SEM-based engagement evaluation system functions not only as a pedagogical diagnostic tool but also as a safeguard of quality of life, supporting a learning experience in which academic achievement and students' emotional and social well-being are mutually reinforcing rather than in tension.

Conclusion

The implementation of the SPOC learning engagement evaluation model significantly enhances the quality of academic life for university students by transforming the digital learning environment into a more supportive and structured experience. By identifying and intervening in the “implicit layers” of learning, specifically emotional and interactive input, the model helps mitigate the frustration and isolation often associated with online education. When students experience high-quality interactions with teachers and peers, their self-efficacy and sense of belonging increase, which directly fosters a more positive, satisfying mental state. This emotional acceptance of the course content encourages students to adopt active learning strategies, reducing the cognitive load and stress that often arise from poorly defined academic tasks.

Furthermore, the model's ability to drive significantly higher and more consistent achievement rates across knowledge, skill, and competency goals ensures that success is distributed more equitably across the student body. This reduction in performance disparities prevents “at-risk” students from falling behind, thereby promoting a more inclusive and fulfilling

educational journey. By leveraging AI-driven feedback systems and longitudinal monitoring, this assessment framework can provide continuous support beyond a single semester, ensuring the transition to blended learning sustains long-term motivation and academic well-being. Ultimately, by aligning instructional design with the psychological and social needs of the learner, the model secures a higher standard of living within the university ecosystem, where academic success is intrinsically linked to individual growth and mental health.

Recommendations

Based on the discussion of data analysis and research conclusions, the following recommendations are made regarding sample size, research scope, and intervention duration.

1. The engagement of university students in SPOC learning needs to be considered comprehensively from multiple perspectives. In this study, the evaluation indicators and dimensions for assessing engagement were explored from students' perspectives. Further consideration should be given to the influence of complex external factors such as schools, educators, and the environment. In teaching practice, the scope can be broadened to explore the impact of external factors such as society, schools, families, and teachers on university students' SPOC engagement, evaluating SPOC engagement more comprehensively and systematically.

2. In the process of university students' SPOC learning, the scope of evaluation of engagement should be expanded. The research sample in this study mainly came from two cities in Liaoning Province, Northeast China. It was concentrated in six universities, totaling 1080 students, of whom 70 participated in the control experiment. Stratified sampling ensured a balance across different schools, majors, and academic years. Extending the research to multiple countries and universities with diverse cultural and institutional environments would strengthen its universality. Comparative studies across countries or regions can also highlight how cultural differences affect communication methods and the support and effectiveness of SPOC learning engagement assessment for teaching models.

3. Research on learning engagement based on the SPOC blended learning model can further employ long-term longitudinal data collection and monitoring to capture the long-term impact of learning engagement on teaching effectiveness. The current intervention measures, based on the "Marketing" course, last 8 weeks, which is sufficient to assess a single course's learning outcomes. For assessing long-term memory, skill transfer, sustained learning motivation,

and the interrelationship between pre- and post-course learning, long-term research can further examine whether students maintain learning engagement in post-course learning and skills training, and the impact of learning engagement intervention on the teaching effectiveness of different types of courses. Further research will enhance the applicability of the assessment model in the implementation of various teaching models.

Recommendation for Further Study

Further research on SPOC learning engagement assessment should incorporate artificial intelligence, such as AI-driven big data feedback systems, audio and video capture technologies for classroom data collection, facial expression recognition technologies, and new technologies like virtual or augmented reality. These can be integrated to create a more representative and adaptable assessment model structure. Future research could also test the integration of learning engagement assessment with teaching models such as flipped classrooms, group task-based teaching, and case-based teaching, going beyond blended learning models to further enhance the assessment model's versatility and support the achievement of various course teaching outcomes.

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