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Original Paper

Research on the Path to Enhance College Students' Deep Learning Ability in SPOC Blended Learning

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Abstract

In the current era of accelerating evolution of the information revolution and the knowledge-intensive social structure, how to shape new types of talents who can adapt to lifelong learning needs and cope with future complex challenges has become a core issue in the process of educational modernization transformation in our country. The shallow and fragmented knowledge imparting model is no longer able to meet the cutting-edge requirements of society for innovation and critical thinking skills, while the thinking integration, mental reconstruction and high-level cognitive development advocated by deep learning are becoming the key paths to lead the rise of educational quality and systematically cultivate learners' critical thinking, creative problem-solving and sustainable learning abilities. At the same time, with the deepening of the digitalization process of education, the purely traditional classroom teaching model is gradually showing limitations in supporting deep learning; while the increasingly mature blended learning model, through the organic integration of direct interaction in face-to-face teaching and flexible resources in online learning, constructs a multi-level, strong support and highly interactive learning ecosystem. This ecosystem not only provides a three-dimensional supporting system of scenario construction, technology empowerment, interpersonal collaboration, resource aggregation and process evaluation for the practice of deep learning, but also provides a promotable practical model for teaching reform in higher education and vocational training fields, and is increasingly highly valued and widely applied by the education community and learners. In the current educational technology development process, how to effectively evaluate the actual effectiveness of deep learning under the blended learning model and systematically explore strategies to enhance deep learning abilities has become an urgent and crucial issue. Building a scientific and comprehensive deep learning ability evaluation model and deeply researching the corresponding ability improvement paths not only has important guiding value for optimizing the teaching design of *blended learning, but also has far-reaching significance for promoting learners to achieve high-quality and sustainable learning development.*

Keywords

SPOC, Blended Learning, Deep Learning

1. Introduction

Driven by the global information revolution, human society has fully entered a high-speed developing information age. This not only significantly increases the scale of talent demand in society, but also sets unprecedentedly high standards for the comprehensive quality and core abilities of talents. In this era, the education system must focus on cultivating new types of talents with lifelong learning capabilities and the ability to adapt to a learning-oriented society and future complex life. This has become the key goal and urgent task of educational development in the information age. To address the multiple challenges brought by the information age, international organizations, such as the National Committee of the United States, have clearly proposed that in the 21st century, talents should systematically master a core competency system including critical thinking, analytical and problem-solving skills, innovation literacy, teamwork, self-management, and autonomous learning skills. The typical feature of the information age is the continuous iteration of information technology, the explosive growth of knowledge, and the exponential increase in the speed of knowledge update. This means that contemporary students will face a more complex, variable, and uncertain life and career environment than before. For a long time, China's higher education system has been to some extent dominated by a knowledge-oriented value orientation, relatively neglecting the coordination and unity of individual development needs and social overall progress. However, the challenges of the information age for higher education are no longer limited to teaching students a large amount of disciplinary knowledge, but rather emphasize how to guide students to engage in meaningful, critical, and in-depth learning. The shallow learning model that relies solely on mechanical memory and repetitive training is no longer able to adapt to the rapidly evolving social reality and career requirements; in contrast, in-depth learning focuses on students' in-depth understanding of knowledge, flexible transfer, and application in real situations, encouraging active exploration, critical reflection, and the integration and construction of the knowledge system. Therefore, it has become an important direction of higher education reform in the information age. Promoting the systematic cultivation of college students' in-depth learning ability is both an inherent requirement of the information age and a necessary trend of current educational reform. Universities must place the promotion of students' in-depth learning and the improvement of their higher-order thinking ability at the core of educational reform, and use this as the orientation to reconstruct the curriculum system, teaching methods, and evaluation mechanisms.

Under the profound impetus of the information revolution, the education sector is undergoing a fundamental paradigm shift. Technological innovation not only reshapes the medium and path of knowledge dissemination, but also poses a fundamental challenge to traditional teaching concepts and models, prompting education to evolve from one-way knowledge transmission to an interactive ecosystem centered on learners. In this process, SPOC, as a refined and contextualized blended teaching model, increasingly highlights its structural value. It does not simply mechanically combine online resources with offline classrooms; instead, through systematic design, it achieves the complementary and deep integration of high-quality digital educational resources and traditional face-to-face teaching, thereby constructing a three-dimensional learning environment that supports individualization, interactivity, and continuous feedback. The SPOC model provides learners with highly contextualized learning tasks, multi-dimensional technological tool support, rich collaboration and reflection opportunities, on-demand customized resource systems, and a combination of process-based and summary-based evaluation mechanisms, offering a crucial support framework for learners to move from surface-level information memorization to deep conceptual understanding, critical thinking, and complex problem-solving abilities. Currently, as higher education increasingly values "21st-century skills", academic discussions and practical focuses on SPOC have shifted from the initial platform establishment and resource accumulation to rigorous assessment of teaching effectiveness and the exploration of optimization strategies. How to effectively promote students' deep cognitive participation and high-level thinking development, and thereby drive the evolution of the overall educational culture, has become a core proposition and frontier topic in educational technology research and teaching reform practice.

2. Theoretical Foundation

2.1 The Deep Learning Theory

Since the theory of deep learning was pioneered by Ference Marton and Roger Säljö, it has been regarded as a systematic learning paradigm centered on the cultivation of higher-order thinking, based on understanding, and dedicated to knowledge transfer and application. This theory not only draws on the essence of behaviorism and cognitivism learning theories, but also reflects a return to the essence of learning, emphasizing that learners actively acquire information, integrate existing knowledge systems, explore solution paths, and thereby achieve effective knowledge transformation and practical problem-solving, ultimately promoting the continuous development of higher-order thinking abilities such as critical thinking and innovative decision-making.

From the theoretical perspective, the intrinsic attributes of deep learning are essentially a comprehensive learning paradigm that integrates higher-order thinking, deep participation, and practical application; in this state, the core competencies of learners, such as innovative thinking, critical thinking, problem-solving, and practical application, can be significantly enhanced. This study aims to construct a systematic and operational evaluation model for deep learning abilities. The logical starting point of this study is to clearly define the connotation and constituent elements of deep learning abilities, and based on this, design the overall framework. During this process, this study can draw on the core competence categories pointed to by the theory of deep learning, decompose and classify them into different dimensions of abilities, and the theory of deep learning, as the theoretical foundation for model construction, provides key theoretical basis and logical guidance for the selection of evaluation elements, the design of the structure, and the establishment of hierarchical relationships, thereby systematically integrating and optimizing the effectiveness and scientificity of the evaluation and the key competence dimensions that deep learning learners should possess.

2.2 The Constructivist Learning Theory

Constructivism, as a core branch within the cognitive learning theory system, has its ideological roots deeply embedded in Piaget's theory of cognitive development and Vygotsky's sociocultural-historical theory. This theory fundamentally redefines our understanding of the essence of learning: it emphasizes that the acquisition of knowledge does not merely result from the one-way indoctrination and transmission by teachers to students. Instead, the learning subject, through in-depth interaction with specific contexts, social environments, and learning partners, uses its existing cognitive structure and experience as a foundation, actively and proactively filters, integrates, and reconstructs new information, thereby achieving personalized meaning generation and knowledge construction.

As a key field for knowledge construction and practical transformation, the modern education system no longer regards students as passive recipients of knowledge, but as active constructors of meaning. The constructivist learning theory profoundly reveals that the essence of learning lies in the process where individuals, in real or simulated situations, through autonomous exploration, social interaction and collaborative reflection, continuously construct and reconstruct their cognitive structures. From this theoretical perspective, the SPOC blended learning model emerged. It not only retains the flexibility and openness of online learning, but also, through systematic teaching design, builds a multi-dimensional support system for students: at the contextual level, it simulates or links to real problem scenarios, prompting learning to occur in concrete environments; at the technical level, with the help of intelligent platforms and tools, it enables the tracking, feedback and personalized adaptation of the learning process; at the interaction level, it constructs a stable and in-depth dialogue channel between teachers and students, as well as among students themselves, encouraging the exchange of viewpoints and collaborative construction; at the resource level, it integrates structured and unstructured learning materials, forming an open, diverse and iterative knowledge ecosystem. In such a supportive environment, students no longer digest knowledge in isolation, but gradually complete the in-depth understanding and meaning generation of complex concepts through collaborative inquiry with peers and in-depth dialogues with teachers. This process not only significantly improves the mastery and transfer of knowledge, but also implicitly cultivates a series of high-order abilities: through group projects, collaborative learning and team coordination skills are cultivated; in solving real problems, analytical and problem-solving abilities are shaped; in evaluating diverse information and viewpoints, critical thinking is developed; in expressing, discussing and feedback, communication and expression abilities are strengthened; and in open tasks, innovative consciousness and creative practice are stimulated. These ability clusters precisely align with the current educational domain's advocated deep learning capabilities. Deep learning is not merely the simple accumulation of knowledge, but emphasizes deep processing of cognition, deep understanding of concepts, and flexible application and innovative output in new situations. Therefore, the SPOC blended learning environment, through its integrated design, actually provides a powerful scaffold and catalyst for learners to enter deep learning. It enables the nurturing and development of deep learning abilities to move from theory to operational, observable and supported teaching practice. To systematically evaluate students' effectiveness in SPOC blended learning, it is not merely limited to surface knowledge tests, but must construct an evaluation model that can scientifically reflect the development level of their deep learning abilities.

3. The Evaluation Model for College Students' Deep Learning Ability in SPOC Hybrid Learning

3.1 The Evaluation Indicators for College Students' Deep Learning Ability in SPOC Hybrid Learning

When examining learning evaluation as the core mechanism for assessing students' academic progress, a systematic and structured evaluation model is not only the foundation for building an evaluation system, but also a prerequisite for implementing effective learning evaluation. Therefore, in order to accurately grasp the deep learning status of learners in the SPOC blended learning mode, constructing a rigorous and scientifically compliant evaluation model becomes a crucial and indispensable task. This article establishes the evaluation index system for college students' deep learning ability in SPOC blended learning through reading domestic and foreign literature, as shown in Table 1.

Table 1. Evaluation Index System for Deep Learning Ability in SPOC Hybrid Learning

Primary Indicator	Secondary Indicator	Problem Number
Cognitive Competence	Critical Thinking	3
	Innovation and Creativity	3
	Problem-Solving Ability	3
	Information Literacy	3
Interpersonal Competence	Effective Communication and Interaction Ability	3
	Collaboration Ability	3
	Leadership	3
Self-Reflection Competence	Autonomous Learning Ability	3
	Developing and Maintaining Academic Ideas	3
Deep Learning Capability	Deep Learning Capability	3

3.2 The Research Method

This article designed a questionnaire based on Table 1. A total of 445 questionnaires were distributed, and 432 were actually returned, with a questionnaire return rate of 97.1%. After manual review and elimination of invalid questionnaires that did not meet the established standards, 413 valid questionnaires were finally obtained, with an effective return rate of 95.6%. The selection of valid questionnaires was mainly based on the following three criteria: First, any unanswered or uncompleted items in the questionnaire are considered invalid; second, those with a total filling time of less than two minutes are judged as invalid; third, if all the answer options in the questionnaire are exactly the same and cannot effectively distinguish the attitude tendencies of the respondents, they are also classified as invalid. Any returned questionnaire that meets any one or more of the above conditions will be eliminated. In confirmatory factor analysis and structural equation model analysis, the sample size has a significant impact on the stability of the analysis results. Generally, it is recommended that the effective sample size be no less than 200. The final effective sample size obtained in this study is 413, which fully meets the basic requirements of model analysis and can provide reliable data support and analysis basis for the current situation and characteristics of college students' deep learning ability in the SPOC blended learning environment. The basic information of the survey subjects is shown in Table 2.

Table 2. Descriptive Statistical Analysis of the Basic Information of the Questionnaire

Basic Information		Number	Proportion
Gender	Male	101	24.56%
	Female	312	75.54%
Grade	Sophomore	112	27.12%
	Junior	132	31.96%
	Senior	169	40.92%
Type	Literature and History	213	51.57%
	Science and Engineering	106	25.67%
	Arts and Sports	94	22.76%

3.3 The Data Analysis

During the analysis of the test questionnaire, reliability analysis is a crucial step to ensure the quality of the data and the credibility of the results. In this study, systematic reliability tests were conducted on the overall structure, cognition, interpersonal relationships, and introspection of the questionnaire, as well as the specific ability variables corresponding to each dimension. The analysis results show that both the overall reliability of the questionnaire and the reliability coefficients of each dimension and its subordinate ability variables have reached the ideal statistical standards, laying a solid foundation for the accuracy and reliability of subsequent research. The detailed reliability test results are summarized in Table 3 for further data verification and in-depth analysis.

The overall reliability analysis of this research questionnaire shows that the Cronbach's α coefficient reaches 0.934, indicating that the questionnaire as a whole has excellent internal consistency and measurement stability. Further tests on each ability dimension revealed that the reliability coefficients of the cognitive ability, interpersonal ability, and introspective ability dimensions were all greater than 0.8, all at an ideal level, suggesting that the structure of each dimension is clear and the relationships between the questions are tight. Additionally, the reliability of each sub-ability element was greater than 0.7, although slightly lower than the dimension level, it still remained within the acceptable reliability range, indicating that each sub-element has certain measurement consistency and reliability. In summary, this questionnaire demonstrates good reliability characteristics in terms of the overall structure, main dimensions, and specific sub-elements, and is suitable for subsequent empirical analysis and research inference.

Table 3. Cronbach's α Test

Variable		Cronbach's α
Cognitive Competence	Critical Thinking	0.716
	Innovation and Creativity	0.824
	Problem-Solving Ability	0.793
	Information Literacy	0.810
	Total	0.894
Interpersonal Competence	Effective Communication and Interaction Ability	0.854
	Collaboration Ability	0.894
	Leadership	0.834
	Total	0.912
Self-Reflection Competence	Autonomous Learning Ability	0.817
	Developing and Maintaining Academic Ideas	0.829
	Total	0.956
Deep Learning Capability	Deep Learning Capability	0.886
Total		0.934

The KMO statistic is an important indicator for assessing whether there is sufficient correlation among variables. Its value ranges from 0 to 1. The closer the value is to 1, the stronger the correlation between the variables is, and the more suitable the data is for factor analysis. According to the criterion proposed by Kaiser, if the KMO value is greater than or equal to 0.9, it indicates that the data is extremely suitable for factor analysis; if it is between 0.8 and 0.9, it means the data is very suitable for factor analysis. In addition, the Bartlett's sphericity test is used to test whether the variables are independent. If the significance Sig value is less than 0.05, it indicates that there is a significant correlation between the variables, and factor analysis is suitable; conversely, if the Sig value is greater than 0.05, it means the independence of the variables is strong, and the factor analysis method is not suitable. Based on the results of these two tests, a scientific judgment can be made on the applicability of factor analysis for the data. This study uses SPSS software to conduct the construction validity test analysis, and the results are summarized in Table 4.

Table 4. KMO and Bartlett's Test

KMO		0.937
Bartlett's Sphericity Test	Approximate Chi-square	589.314
	df	435
	P	0.000

As can be seen from Table 4, the KMO value of this questionnaire survey is 0.937, indicating that the collected questionnaire data have good reliability.

4. The Path for Enhancing College Students' Deep Learning Ability in SPOC Hybrid Learning

4.1 The Empirical Analysis

This paper uses the structural equation model to analyze the factors influencing deep learning ability. The data structure is shown in Table 5.

Based on the analysis results of the structural equation model, all nine key sub-abilities have a significant positive promoting effect on deep learning ability. Among them, the influence of effective communication and interaction ability is the most prominent (with a path coefficient of 0.987), while the influence of information literacy is relatively weak (with a path coefficient of 0.497). This difference mainly stems from the typical learning context characteristics in the SPOC blended learning environment: learners are often in a regular environment of group collaboration, discussion and resource sharing. Communication and interaction thus become the core mechanism for promoting the process of deep learning. Actively participating in discussions not only helps learners clearly express their own viewpoints and deepen their understanding of the content, but also promotes the confrontation of thinking and the collision of viewpoints, enabling learners to critically examine others' opinions while continuously optimizing their cognitive structure, thereby significantly improving deep learning ability. This also explains why critical thinking and collaboration ability have a similarly significant impact on deep learning. On the other hand, blended learning is highly dependent on the resource-oriented learning model, and as digital natives, the student group generally has strong adaptability to information technology and information processing foundation, and can relatively calmly deal with diverse and even uneven information environments. Therefore, in this context, the direct contribution of information literacy to deep learning ability is relatively limited. However, this does not mean that information literacy is insignificant in the development of deep learning; on the contrary, in an increasingly complex information ecosystem, high-level information screening, evaluation and integration abilities are still important foundations for supporting in-depth exploration and continuous learning, and their role is more reflected in the long-term empowerment of learning quality and validity.

Table 5. The Path Coefficient for Enhancing College Students' Deep Learning Ability in SPOC Hybrid Learning

Influence Path	Estimate Normalizing Parameter	P	Factor Loadings(λ)
Critical Thinking <--- Deep Learning Capability	0.894	***	0.855
Innovation and Creativity <--- Deep Learning Capability	0.734	***	0.722
Problem-Solving Ability <--- Deep Learning Capability	0.634	***	0.745
Information Literacy <--- Deep Learning Capability	0.497	***	0.399
Effective Communication and Interaction Ability <--- Deep Learning Capability	0.987	***	0.935
Collaboration Ability <--- Deep Learning Capability	0.811	***	0.806
Leadership <--- Deep Learning Capability	0.793	***	0.651
Autonomous Learning Ability <--- Deep Learning Capability	0.746	***	0.730
Developing and Maintaining Academic Ideas <--- Deep Learning Capability	0.630	***	0.755

5. The Paths for Enhancing College Students' Deep Learning Abilities

5.1 To Strengthen the Ability of Effective Communication and Interaction

The effective enhancement of deep learning ability depends on a high-quality interpersonal interaction environment and the design of positive communication activities. When learners are immersed in a democratic, equal, and supportive communication atmosphere, they are more likely to experience pleasure and a sense of achievement during learning, thus being more willing to express their viewpoints, think deeply, and conduct in-depth processing of knowledge. By constructing diverse and cross-disciplinary discussion scenarios, continuously stimulating the participation of learners, and combining the guidance of communication skills and the training of emotional empathy, the quality of substantive communication between teachers and students, as well as among students themselves, can be effectively enhanced. This, in turn, further promotes learners to achieve a deepening process from surface memorization to deep understanding and application creation. Therefore, creating a learning environment conducive to idea collision and emotional connection, and organizing systematic interactive training, are indispensable core links in promoting the process of deep learning.

5.2 To Enhance Critical Thinking Skills

Under the SPOC teaching model, the offline learning environment retains the traditional face-to-face classroom format. This direct interactive teaching method not only enables high-density exchanges of various viewpoints and opinions in a short period of time, but also effectively enhances the learners' sense of integration in the classroom, allowing them to quickly and efficiently engage in in-depth discussion sessions based on their self-study before the class. In the specific implementation, we adopt a teaching strategy centered on offline debates, supplemented by lectures and Q&A. For example, in the traditional classroom session, the teacher first conducts centralized Q&A on the questions collected and sorted out during the online mutual evaluation stage to optimize the efficiency of time utilization; then, a classroom debate activity is organized. Based on the personal viewpoints that learners have formed through the previous online mutual evaluation, the teacher or teaching assistant can divide the learners into different debate groups according to the differences in viewpoints, thereby guiding the debate to proceed. During the debate, learners constantly examine and analyze the rationality of their own and others' viewpoints, provide feedback through questioning, and continuously correct and improve their own viewpoints based on the feedback. This process not only stimulates the collision and integration of diverse viewpoints, but also plays a significant role in promoting the cultivation and development of learners' critical thinking.

5.3 To Achieve Independent and Autonomous Learning

In the process of guiding learners to engage in autonomous learning, the role of the facilitator is of utmost importance, and its function should be systematically manifested in three core aspects. The primary task is to enhance the learners' time management skills - in today's fast-paced society, efficient time management has become an indispensable survival skill for everyone. The facilitator can clearly convey the key time points of each learning stage through regular emails, learning platform announcements, etc., such as the opening time of courses, the cycle of content updates, and the deadline for submitting assignments, thereby assisting learners in planning their learning process reasonably and promoting their continuous monitoring of their own learning progress. Secondly, the facilitator needs to focus on guiding learners to establish scientific learning goals and paths, encouraging them to set long-term visions and short-term tasks based on their personal long-term development needs, current course requirements, interests, and learning habits, and break these goals down into actionable phased plans. Finally, the facilitator should promote learners to establish personalized learning schedules, emphasizing their learning autonomy as independent individuals, and helping them break away from the passive following mentality in traditional group teaching. For example, learners can prepare time arrangements based on task priority and their own learning efficiency, execute them in order of importance, and conduct regular reviews and reflections after execution, and promptly adjust time allocation, progress planning, or learning strategies. In addition, teachers or facilitators also need to provide timely and targeted feedback on learners' self-paced learning process, actively cultivating their abilities of self-monitoring, evaluation, reflection, and adjustment in learning, thereby effectively improving their autonomous learning levels.

6. The Conclusion

This study is based on the essential connotation of deep learning ability as its theoretical foundation. It systematically integrates the influential deep learning ability frameworks and their key influencing factors from both domestic and international sources, and closely combines the unique characteristics of the SPOC blended learning model to construct a logically rigorous and hierarchical conceptual model of deep learning ability. On this basis, a more operational and valid evaluation model of deep learning ability has been further developed, providing a research framework that combines theoretical depth and practical guidance for the development and scientific assessment of students' deep learning ability in blended learning environments. Based on the analysis results of the structural equation model, this study innovatively constructs a quantitative evaluation system for deep learning ability. Specifically, using the standardized path coefficients obtained from confirmatory factor analysis, we systematically solved and determined the weight distribution of each secondary evaluation indicator and its subordinate sub-ability dimensions. On the basis of the empirical model, this paper further proposes targeted ability advancement strategies and operational suggestions from core abilities such as effective communication and collaboration, critical thinking and reasoning skills, and autonomous inquiry learning, aiming to provide theoretical basis and practical guidance for the systematic cultivation and assessment of deep learning ability.

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