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Blended Learning Effectiveness and College Students' Deep Learning Perceptions: The Community of Inquiry Perspective

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Abstract

Emerging technologies and innovative instructional methods have revolutionized education, making blended learning the new standard in the artificial intelligence era. However, poor integration of online and face-to-face learning has led to challenges such as superficial student engagement. This study developed a Community of Inquiry-based blended learning model and evaluated its effectiveness with 92 college students using a quasi-experimental approach. Over 16 weeks, the experimental group ($n = 48$) adopted the blended learning model, while the control group ($n = 44$) used traditional learning conditions. Learning effectiveness and deep learning perceptions were evaluated, revealing the blended learning group demonstrated superior learning effectiveness ($d = 0.83$) and reported higher deep learning perceptions ($\eta 2 = .05–.072$) compared to the traditional learning group. These results provide valuable insights for educators aiming to design blended learning models that foster deep learning and improve overall learning effectiveness.

Keywords: blended learning, learning effectiveness, deep learning perception, Community of Inquiry, CoI, higher education

Introduction

The widespread adoption of digital technologies has transformed education, leading to the rise of diverse instructional methods such as online learning and personalized instruction, which have spurred the growth of blended learning (Perera et al., 2020). Blended learning, which combines the strengths of traditional and online education, addresses the limitations of both methods and plays a crucial role in enhancing teaching quality and talent development (Han, 2023). In such environments, educators guide students in cultivating creativity, problem-solving, and deep learning skills, all essential for higher education reform and the 21st-century workforce (Qi et al., 2020).

The Community of Inquiry (CoI) framework is an effective model for designing blended environments, promoting learning engagement through active participation, meaningful discussion, and timely instructor feedback (Armellini et al., 2021; Liu & Deris, 2022). The three key elements of the CoI framework—teaching presence, social presence, and cognitive presence—are vital for enhancing students' knowledge acquisition, skill development, and motivation (Zhang, 2020).

Empirical research has suggested that students in blended learning environments tend to achieve superior learning outcomes and report more positive learning experiences compared to those in traditional classroom settings (Vallée et al., 2020). The CoI framework further supports blended course design by fostering collaboration, critical thinking, and meaningful knowledge construction (Zhang, 2020). Despite these promising findings, further research is required to determine whether CoI-based blended learning is more effective than traditional pedagogical methods in enhancing both learning outcomes and deep learning. This study addressed this gap by investigating the effectiveness of a CoI-based blended learning model, facilitated through the Superstar Learning platform (https://www.chaoxing.com/), in promoting high-quality learning experiences. By examining the impact of this model, the study contributes to the growing body of research on evidence-based frameworks for blended learning, offering valuable insights for educators and instructional designers seeking to optimize student engagement and academic achievement.

The Blended Learning Effect

Blended learning is widely recognized for improving learning outcomes, especially when using diverse information and communications technology tools and resources that create immersive, student-centered environments (Bizami et al., 2023; Shamir-Inbal & Blau, 2021). These environments effectively enhance learning by integrating traditional and digital methods. For instance, Li and Cao's (2020) blended learning model for undergraduate English students combined virtual reality, online content, and interactive classroom sessions, significantly improving test scores. Similarly, Antonelli et al. (2023) found that virtual reality labs reduced student errors and enhanced practical skills. Through a systematic review, Almusaed et al. (2023) confirmed that blended learning environments enabled with artificial intelligence (AI) have the potential to enhance educational quality. Technologies such as chatbots, intelligent tutoring systems, and personalized learning platforms can increase student engagement and support motivation.

Blended learning also fosters deep learning competencies. Innovative models, such as micro-learning and computer-based collaborative learning, have improved students' self-learning abilities and goal achievement (Astiwardhani Sobandi, 2024). Courses incorporating video lectures and online materials have boosted English learners' motivation, autonomy, and satisfaction (Wang et al., 2021). Zhao (2022) leveraged the Rain Classroom platform's network and mobile technologies (https://www.yuketang.cn/en) to create a blended model that increased learning quality and interest. Similarly, AI-powered blended courses have been more effective than traditional teaching in promoting student engagement, deep learning, critical thinking, and independent and cooperative learning (He et al., 2023).

Deep Learning Dimensions

Unlike surface learning, which focuses on memorization driven by external motivation, deep learning fosters meaningful knowledge construction and intrinsic motivation (Darling-Hammond & Oakes, 2021). Deep learning encourages learners to engage deeply with content, develop critical thinking and problem-solving skills, and enhance knowledge transfer (Shen & Chang, 2023). It also promotes skills such as learning how to learn, complex problem-solving, and effective communication and collaboration (Mthethwa-Kunene et al., 2022).

At the core of deep learning is the development of higher-order cognitive abilities, including problem-solving, decision-making, and critical thinking (Kurniawan, 2021). This process empowers students to creatively solve real-world problems (Pan et al., 2023). Mobile technology has been shown to support higher-order thinking by providing timely access to information and facilitating active cooperation and engagement (Hye et al., 2020; Yaniawati et al., 2022). Hu and Hwang (2024) proposed a problem-posing approach that was mobile, self-adapted, and based on concept mapping within a virtual museum context and found that it significantly enhanced learners' critical thinking and problem-solving abilities. In this study, learning behaviors involving application, analysis, evaluation, and creation were categorized as higher-order cognition.

Deep learning also emphasizes communication and collaboration, essential 21st-century skills (Mthethwa-Kunene et al., 2022). Effective communication involves organizing learning content through presentations, group work, and interactive projects, while collaboration focuses on learner-centered activities such as sharing, interaction, and discussion (Islam et al., 2022; Mthethwa-Kunene et al., 2022). Interactive learning is supported by flipped classroom models that promote active communication through online and in-person discussions and timely feedback (Shen & Chang, 2023). Blended learning, incorporating diverse computer-mediated collaboration strategies, enhances participation and student satisfaction (Belda-Medina, 2021; Vlachopoulos & Makri, 2019). Intelligent computers can simulate interactions between learners and the external environment by performing tasks and providing timely feedback based on individual mistakes. Additionally, collaboration between AI and learners has the potential to optimize learning outcomes (Weber et al., 2025).

Reflective thinking is another key aspect of deep learning, focusing on self-reflection in academic research and practice (Rogers et al., 2019). It plays a crucial role in shaping students' professional identity and ensuring sustainable learning (Annansingh, 2019). Reflective learning involves both self-reflection and reflection on others' learning behavior (Priddis & Rogers, 2018). Intelligent learning tools—such as ChatGPT, Apple's Shortcuts, and LINE—have been shown to facilitate this process by enabling students to monitor their progress and develop reflective thinking skills (Wu et al., 2023). In this study, reflective learning primarily involved learning under supervision and guidance.

Lastly, emotional experience is a hallmark of deep learning (Pellegrino & Hilton, 2012). Self-efficacy, motivation, and positive attitudes toward learning significantly impact engagement and effectiveness

(Meyer et al., 2018). Well-designed online and face-to-face activities in blended courses can foster positive attitudes, while clear goals and challenging tasks can enhance self-efficacy and motivation (Zhao & Song, 2022; Zhao et al., 2021). In this study, emotional experiences included learning attitudes, self-efficacy, and motivation.

Research Hypotheses

This study operationally defined four core features of deep learning: higher-order cognition, interactive learning, reflective learning, and emotional experience. It measured students' deep learning perceptions in these four dimensions to verify the effectiveness of the CoI-based blended learning model. Furthermore, this study, using the Digital Film and Television Directing and Production course as an example, applied a CoI-blended learning model and compared the blended (BL) and traditional (TL) classroom learning outcomes represented by three scores: online quizzes, a final exam, and film and television assignments.

While prior research has generally supported the efficacy of blended learning, some studies have reported no significant differences in learning outcomes between BL and TL students (e.g., Müller & Mildenberger, 2021). These discrepancies may stem from inadequate instructional design, insufficient scaffolding, superficial integration of online and offline learning, and underuse of the potential benefits of blended learning. The CoI framework, which focuses on enhancing students' learning presence, can effectively guide the design of blended learning activities, fostering a more seamless integration of online and face-to-face learning modes (Armellini et al., 2021). CoI-based blended courses are expected to promote deep learning and improve overall learning effectiveness by balancing online and offline instruction (Tabassum & Mohd Saad, 2024).

Thus, the following hypotheses were proposed:

- H1: BL students will exhibit significantly higher learning effectiveness than TL students.

    H1-1a: BL students will achieve higher scores on lower-order online quiz questions.

    H1-1b: BL students will achieve higher scores on higher-order online quiz questions.

    H1-2a: BL students will achieve higher scores on lower-order final exam questions.

    H1-2b: BL students will achieve higher scores on higher-order final exam questions.

    H1-3: BL students will score significantly higher on film and television assignments.

- H2: BL students will demonstrate stronger deep learning perceptions than TL students across the following dimensions:

    H2-1: Higher-order cognition

    H2-2: Interactive learning

    H2-3: Reflective learning

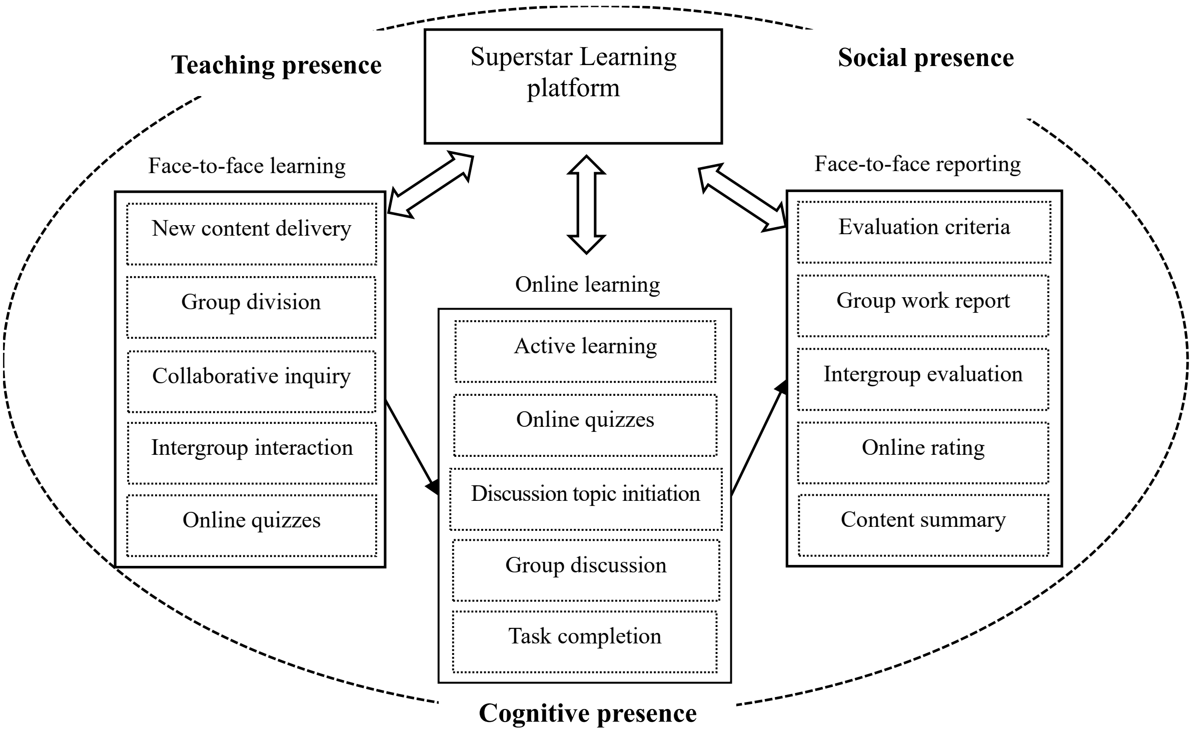
H2-4: Emotional experience

Community of Inquiry-Based Blended Learning Model Design

This study examined the implementation of a blended learning model in the Digital Film and Television Directing and Production course, using the Superstar Learning platform developed by Beijing Century Superstar Information. The model integrated three key elements of the community of inquiry (CoI) framework: teaching, social, and cognitive presence, within three learning stages—face-to-face learning, online learning, and face-to-face reporting (Figure 1). The 16-week course was divided into three phases: early creation, mid-stage shooting, and post-editing, with the initial week dedicated to orientation and the remaining time equally distributed across the three teaching modules.

Figure 1

The CoI-Based Blended Learning Model



Note. CoI = Community of Inquiry.

The course design and implementation effectively addressed the three elements of the Community of Inquiry (CoI) framework. In terms of teaching presence, the course featured clearly defined learning objectives, detailed syllabi, and well-organized materials, while instructors actively provided timely feedback and facilitated problem-solving discussions. The intelligent learning platform further enabled tailored instructional strategies by monitoring student progress and adjusting content delivery accordingly.

Regarding social presence, the curriculum incorporated collaborative activities, such as online discussion forums, group projects, and peer reviews, which fostered a sense of community among students. Real-time communication tools and virtual breakout sessions were employed to enhance interaction and support, while integrated social networking features promoted informal exchanges of ideas beyond formal class sessions.

In addressing cognitive presence, the course used inquiry-based tasks, case studies, and problem-solving assignments to encourage critical analysis and reflective thinking. Interactive modules and scenario-based exercises were implemented to deepen understanding and facilitate the application of theoretical concepts, while continuous reflection activities, including reflective journals and self-assessment quizzes, supported the development of critical thinking and knowledge construction.

Face-to-Face Learning Stage

In this stage, in-class learning was paired with the Superstar Learning platform. The first two weeks of each module followed a structured five-step process:

1. The teacher introduced new concepts, encouraging active participation.
2. Students formed self-selected groups and learning behavior norms for participation.
3. Inquiry tasks were assigned, prompting group discussions and collaborative exploration. Results were uploaded to the platform.
4. Groups conducted peer evaluations, refining their work based on feedback, with guidance from the teacher.
5. Online quizzes assessed learning outcomes, followed by teacher feedback and content summaries.

Online Learning Stage

This stage featured three online discussion questions and one practice task, each spanning 2 weeks and following five steps:

1. The teacher provided learning materials (video, PowerPoints, quizzes) on the platform for students to engage with independently.
2. Students completed online quizzes with immediate feedback, and the teacher provided support when needed.
3. The teacher initiated discussions, with students tackling two discussion questions in the first week and one in the second.
4. Group leaders supervised discussions, fostering deeper engagement and collaboration, while the teacher facilitated reflection and knowledge co-construction.
5. Groups completed tasks based on discussion outcomes and uploaded their work to the platform.

Face-to-Face Reporting Stage

This stage focused on the online learning tasks and summarizing content. The last week of each learning module followed a five-step process.

1. The teachers shared evaluation criteria, and students familiarized themselves with the guidelines.

2. Group representatives presented their work, showcasing innovative ideas and application of new concepts. Other groups and the teacher provided feedback.

3. Intergroup evaluations were conducted, with students providing feedback based on evaluation criteria and engaging in on-site discussions.

4. Groups posted online ratings and comments on other groups' work, and the teachers stored the evaluation results for post-class review.

5. The teachers guided students through content summarization, encouraging critical thinking and integration of new material

Research Methodology

Participants

The participants were 92 sophomore educational technology students enrolled in the two compulsory Digital Film and Television Production classes at a university in China in the spring semester of 2023. Both classes lasted for 16 weeks and were taught by the same teacher. One class was randomly assigned as the experimental group (n = 48), while the other class was the control group (n = 44). The male-female ratio for the experimental and control groups were 1:2 (16 males and 32 females) and 1:2.4 (13 males and 31 females), respectively. All students were between 19 and 21 years old, owned smartphones, and were proficient Superstar Learning platform users.

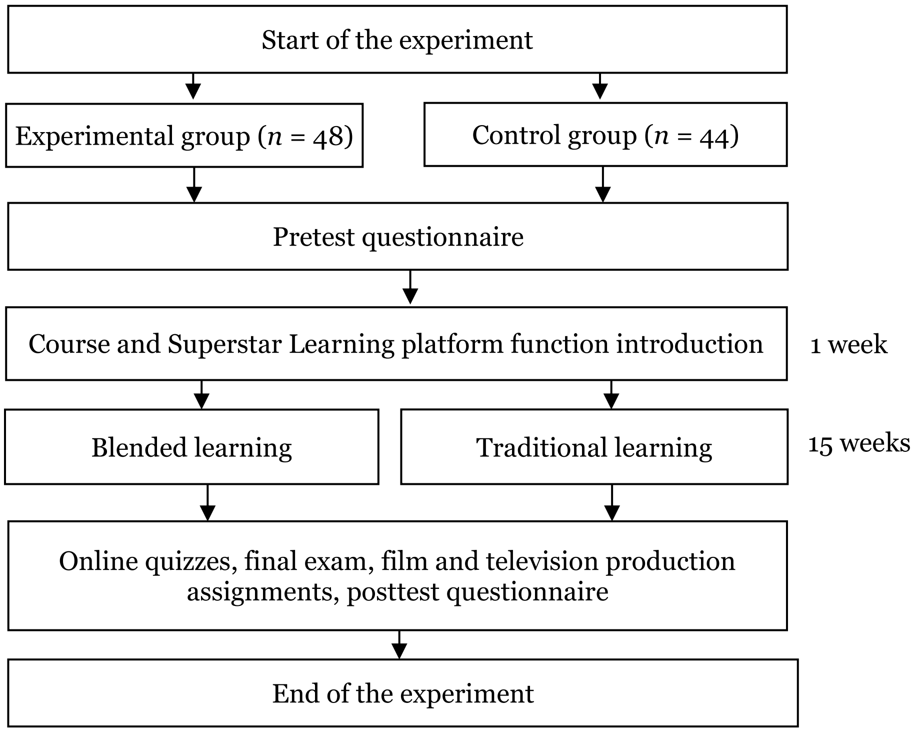
The final exam scores from the prerequisite course Fundamentals of Photography Skills served as the prior knowledge assessment criteria. Independent sample t-test results indicated that there were no statistically significant prior knowledge differences ($t = 0.86$, $p > .05$) between the experimental group, $M(SD)$ = 81.38(7.47), and the control group, $M(SD)$ = 80.11(6.59).

Experimental Procedure

This study focused on learning effectiveness and students' deep learning perceptions in the CoI-based blended learning course (Figure 2). In the pre-intervention stage, the participants took the pretest and were introduced to the basic functions of the Superstar Learning platform. In the intervention stage, while both groups participated in face-to-face learning with some Superstar Learning activities done in class, only the experimental group took part in the online learning stage. The control group students listened to the teacher's lectures, participated in class discussions, collaborated in groups, completed online quizzes, and completed the same post-class learning tasks. As the Digital Film and Television Directing and Production course focused on both theory and practice, students in both groups were required to take the final exam and submit comprehensive film and television production assignments. At the end of the course, both groups completed the perception posttest.

Figure 2

Experimental Procedure



Instruments

This study used various assessments to compare learning effectiveness between students in blended and traditional learning environments: online quizzes, a final exam, and group assignments. Additionally, pre- and posttests were conducted to measure deep learning perceptions in both groups.

Online Quizzes

On the Superstar Learning platform, both groups completed identical online quizzes, worth 280 points in total, consisting of 64 single-choice questions (128 points), 26 multiple-choice questions (104 points), and 6 essay questions (48 points). Based on Bloom's revised taxonomy (Krathwohl, 2002), the quizzes were divided into lower-order (knowledge and comprehension) and higher-order (application, analysis, and evaluation) cognitive levels. Lower-order questions totaled 186 points, while higher-order questions totaled 94 points.

Final Exam

Both groups took the same final exam, categorized into lower-order and higher-order cognitive questions. For instance, a lower-order question required students to briefly describe the fundamental principles of shot assembly, whereas a higher-order question asked them to provide an example of how the close-up method is applied in effect sound processing. The exam was worth 100 points, with 10 fill-in-the-blank questions (20%), 15 multiple-choice questions (30%), 5 brief questions (35%), and 1 design question (15%). Each cognitive level accounted for 50 points. Content validity was reviewed by three educational technology experts with over 10 years of experience.

Film and Television Production Assignments

Students worked in groups to produce 10-minute films on self-chosen themes. Each class was divided into six groups. To assess individual contributions, students provided task descriptions in their final reports. The total score (100 points) consisted of intragroup scores (30%), intergroup score (30 points), and the teacher's evaluation (40%).

Deep Learning Perception Scale

The questionnaire comprised two sections. The first section collected students' basic information, including student number, gender, and experience with the Superstar Learning platform. The second section contained the 20-item Deep Learning Perception Questionnaire (DLPQ), designed to measure students' perceptions of deep learning. Items related to higher-order cognition, interactive learning, and reflective learning were adapted from Shen and Chang (2022), while emotional experience items were synthesized from Alqurashi (2019) and Zimmerman and Kulikowich (2016). Responses were scored on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). To ensure content validity, three experts with over 10 years of experience in educational technology reviewed the scale, refining item structure, clarifying meanings, and offering revision suggestions. The finalized questionnaire was pretested with 156 students informed of the study's purpose, yielding 122 valid responses and a return rate of 78.2%.

Exploratory factor analysis (EFA) was conducted using IBM SPSS Statistics (Version 25.0) to evaluate the DLPQ's factor structure. Results are shown in Table 1. The Kaiser-Meyer-Olkin value was 0.83, and Bartlett's chi-square value was 1573.67 (df = 190, p < .001), indicating the scale's suitability for factor analysis. Principal component analysis with the maximum variance method was employed to analyze the pretest data. Factors were selected based on eigenvalues greater than 1, with item retention requiring factor loadings exceeding 0.5. The analysis revealed four dimensions, explaining a cumulative variance of 66.78% (see Table 1). The interactive learning dimension (5 items, e.g., "I can offer useful suggestions for my peers") accounted for close to half the variance, with factor loadings ranging from 0.64 to 0.86. The reflective learning dimension (5 items, e.g., "I can analyze the reasons for failure to solve problems") explained around another one tenth of the variance, with loadings from 0.51 to 0.83. The higher-order cognition dimension (5 items, e.g., "I can find logical relationships between knowledge points") accounted for an additional small percentage of the variance, with loadings between 0.64 and 0.75. Finally, the emotional experience dimension (5 items, e.g., "I am willing to adjust my learning style to meet course requirements") explained a further small fraction of the variance, with loadings from 0.60 to 0.83. These findings indicate strong structural validity for the scale. Additionally, Cronbach's alpha values for the four dimensions demonstrated good reliability.

Table 1

The Reliability and Validity of DLP Scale

Item	Dimension			
	Interactive learning	Reflective learning	Higher-order cognition	Emotional experience
HC1			0.69	
HC2			0.75	
HC3			0.75	
HC4			0.73	
HC5			0.64	
IL6	0.64			
IL7	0.74			
IL8	0.86			
IL9	0.69			
IL10	0.77			
RL11		0.62		
RL12		0.83		
RL13		0.72		
RL14		0.72		
RL15		0.51		
AE16				0.67
AE17				0.67
AE18				0.68
AE19				0.60
AE20				0.83
Cronbach's α	0.88	0.86	0.83	0.87
Eigenvalues	8.84	1.83	1.52	1.17
Variance (%)	44.19	9.13	7.62	5.84
Cumulative variance (%)	44.19	53.32	60.94	66.78

Note. DLP = deep learning perception; HC = higher-order cognition; IL = interactive learning; RL = reflective learning; AE = emotional experience

Data Collection and Analysis

Learning Effectiveness

The learning effectiveness data came from online quizzes (30%), film and television assignments (30%), and a final exam (40%). For online quizzes, the objective questions (single-choice, multiple-choice) were automatically scored by the Superstar Learning platform, while the teacher scored the subjective questions (essay questions). The assignment scores comprised the weighted average of the students' and teacher's scores. The final exam papers were graded solely by the teacher. An independent sample *t*-test was used to explore the differences between the two groups in the lower-order cognitive and higher-order cognitive questions on the online quiz and final exam scores, as well as in the assignment scores.

A significance level of $p < .05$ was adopted, and Cohen's *d* was used to measure the effect size to evaluate further differences between the experimental and the control groups. Cohen's *d* values of 0.2~0.5 represented a small effect size, 0.5~0.8 denoted a medium effect size, and values greater than 0.8 indicated a large effect size (Cohen, 1988).

Deep Learning Perception

Formal questionnaires were administered to investigate the pretest and posttest deep learning perceptions in both the experimental and the control groups. A total of 92 students completed the questionnaire. Out of 48 students in the experimental group, 46 submitted valid questionnaires, resulting in a high return rate of 95.8%. Out of 44 students in the control group, 41 submitted valid questionnaires, with a robust return rate of 93.2%.

Descriptive statistics were used to analyze the pre- and posttest data probing students' higher-order cognition, interactive learning, reflective learning, and emotional experience. Mean and standard deviation were employed to assess students' deeper learning perceptions in four dimensions. Subsequently, covariate analysis was conducted to examine the deep learning perception differences between the experimental and the control groups. η2 was reported to calculate the effect size, with values .01~.07 indicating a small effect size, values .07~.14 denoting a moderate effect size, and values greater than .14 signifying a large effect size (Cohen, 1992).

Research Results

Learning Effectiveness

There was a significant difference in the learning effectiveness between the experimental and the control groups (Table 2). The experimental group achieved significantly better learning outcomes than the control group, with a large effect size. These findings support hypothesis H1.

Table 2

Learning Effectiveness Differences

Score source	Experimental (*n* = 48)		Control (*n* = 44)		*t*	Cohen's *d*
	M	SD	M	SD		
Lower-order questions (Online quizzes)	179.63	5.74	177.41	7.04	1.66	0.35
Higher-order questions (Online quizzes)	86.67	6.21	82.41	8.22	2.78**	0.58
Lower-order questions (Final exam)	36.88	6.98	34.14	6.36	1.96	0.41
Higher-order questions	36.54	6.82	32.39	5.09	3.29***	0.69

Score source	Experimental (*n* = 48)		Control (*n* = 44)		*t*	Cohen's *d*
	M	SD	M	SD		
(Final exam)						
Film and television assignments	88.81	3.94	86.86	4.14	2.31*	0.48
Learning effectiveness	84.54	5.35	80.51	4.34	3.95***	0.83

Note. *$p < .05$. **$p < .01$. ***$p < .001$.

Also shown in Table 2, there were no significant differences between the experimental and control groups in lower-order question scores for online quizzes and final exam scores, indicating that hypotheses H1-1a and H1-2a were not supported. However, the experimental group scored significantly higher than the control group on higher-order questions in the online quizzes, with a moderate effect size. Similarly, for the final exam, the experimental group outperformed the control group on higher-order question scores, thereby supporting hypotheses H1-1b and H1-2b.

In terms of film and television assignment scores, Table 2 shows a significant difference. The mean assignment score for the experimental group was significantly higher than that of the control group. Although the effect size was small, these findings suggest that students in the experimental group achieved significantly better performance in practical tasks compared to those in the control group, thus supporting hypothesis H1-3.

Deep Learning Perceptions

This study assessed deep learning perceptions across the dimensions of higher-order cognition, interactive learning, reflective learning, and emotional experience both before and after the completion of the blended course. The findings are shown in Table 3. Results indicated that prior to the course, all students' deep learning competencies in these dimensions were above average, with scores ranging from 3 to 4. After engaging in the blended course, these competencies approached a score of 4, reflecting a significant enhancement in the deep learning abilities of the experimental group. In contrast, the control group, in post-test results, showed less of an improvement, suggesting that the blended learning model played a role in enhancing deep learning competencies.

Table 3

Deep Learning Perceptions in the Experimental and Control Groups

Dimension		Experimental		Control	
		M	*SD*	*M*	*SD*
Higher-order cognition	Pretest	3.59	0.57	3.60	0.46
	Posttest	3.96	0.55	3.76	0.46
Interactive learning	Pretest	3.52	0.50	3.59	0.56
	Posttest	3.90	0.56	3.73	0.44
Reflective learning	Pretest	3.48	0.49	3.50	0.49

Dimension		Experimental		Control	
		M	*SD*	*M*	*SD*
	Posttest	3.89	0.49	3.73	0.41
Emotional experience	Pretest	3.49	0.49	3.54	0.49
	Posttest	3.95	0.53	3.77	0.38

Covariate analysis was performed to assess the model's effectiveness further and to elucidate the disparities in higher-order cognition, interactive learning, reflective learning, and emotional experience between the two groups. The results of the intragroup regression coefficient homogeneity test revealed that none of the dimensions reached the significance level: for high-order cognition, $F = 3.23$, $p > .05$; for interactive learning, $F = 0.04$, $p > .05$; for reflective learning, $F = 0.89$, $p > .05$; and for emotional experience, $F = 0.26$, $p > .05$. Consequently, the null hypotheses were accepted, aligning with the assumption of homogeneity of regression coefficients in covariate analysis, justifying the continuation of covariate analysis.

Covariate analyses results revealed significant perception differences between the two groups. Specifically, significant differences were found in higher-order cognition, interactive learning, reflective learning, and emotional experience perceptions, revealing small effect sizes in the first three dimensions (tables 4, 5, and 6) and moderate effect size in the last dimension (Table 7). These findings suggest that students enrolled in the CoI-based blended course had significantly more positive higher-order cognition, interactive learning, reflective learning, and emotional experience perceptions than their traditional classroom counterparts, thereby supporting hypotheses H2-1, H2-2, H2-3, and H2-4.

Table 4

Higher-Order Cognition Perception Differences

Source	*SS*	*df*	*MS*	*F*	η^2
Intervention	8.99	1	8.99	61.32^{***}	.42
Experimental effect	0.62	1	0.62	4.25^{*}	.05
Residuals	12.32	84	0.15		
Interpreted sum	21.88	86			

Note. $R^2 = .44$ (Adjusted $R^2 = .42$).
$^{*}p < .05$. $^{***}p < .001$.

Table 5

Interactive Learning Perception Differences

Source	*SS*	*df*	*MS*	*F*	η^2
Intervention	8.76	1	8.76	59.26^{***}	.41
Experimental effect	0.69	1	0.69	4.64^{*}	.05

Source	*SS*	*df*	*MS*	*F*	η²
Residuals	12.41	84	0.15		
Interpreted sum	21.56	86			

Note. R^2 = .42 (Adjusted R^2 = .41).
$^{*}p$ < .05. $^{***}p$ < .001.

Table 6

Reflective Learning Perception Differences

Source	*SS*	*df*	*MS*	*F*	η²
Intervention	7.91	1	7.91	77.57***	.48
Experimental effect	0.44	1	0.44	4.31*	.05
Residuals	8.57	84	0.10		
Interpreted sum	16.84	86			

Note. R^2 = .49 (Adjusted R^2 = .48).
$^{*}p$ < .05. $^{***}p$ < .001.

Table 7

Emotional Experience Perception Differences

Source	Sum of squares	df	Mean of squares	F	η²
Intervention	6.47	1	6.47	45.43***	.35
Experimental effect	0.93	1	0.93	6.54*	.072
Residuals	11.96	84	0.14		
Interpreted sum	19.15	86			

Note. R^2 = .38 (Adjusted R^2 = .36).
$^{*}p$ < .05. $^{***}p$ < .001.

Discussion

Students' Learning Effectiveness

The findings support hypothesis H1, indicating that students in the blended learning (BL) group demonstrated significantly better learning effectiveness than those in the traditional learning (TL) group. This aligns with previous studies, such as Vallée et al. (2020), which found that students in blended learning environments exhibited superior learning outcomes compared to their traditional counterparts. Similarly, Yin and Yuan (2021, 2022) concluded that CoI-based blended learning models not only increased learning interest but also positively impacted academic performance, suggesting that the structure of blended learning fosters deeper engagement and critical thinking, which can enhance learning quality beyond traditional methods (Vo et al., 2017).

For hypotheses H1-1a and H1-2a, no significant difference was observed between the BL and TL groups on lower-order cognitive questions. This finding may be attributed to the independent learning ability required for mastering lower-order cognitive content, where learning methods appear to have less impact. This result is consistent with Shen and Chang (2023), who found that the instructional approach had limited influence on students' mastery of lower-order cognitive knowledge. Similarly, Lozano-Lozano et al. (2020) reported no significant differences between BL and TL students in their comprehension of theoretical knowledge.

In contrast, hypotheses H1-1b and H1-2b were supported, with BL students scoring significantly higher on higher-order cognitive questions compared to their TL peers. This confirms that blended learning has a substantial impact on students' understanding of higher-order cognitive knowledge, consistent with prior research on CoI-based models. Blended learning promotes deeper cognitive engagement, allowing students to move beyond superficial learning and engage in higher-order thinking, leading to improved academic performance and greater understanding of complex concepts (Chen, 2022; Guo et al., 2021). The integration of inquiry-based learning and open communication within the CoI framework enhances social presence, which, in turn, positively affects students' performance on higher-order cognitive tasks (Tan, 2021). These findings emphasize the importance of designing blended learning activities that foster teaching, cognitive, and social presence to enhance higher-order cognitive skills (Kurniawan, 2021). Given the distinct advantage of BL in fostering higher-order thinking, educators should carefully consider the cognitive complexity of the content when designing such courses.

Hypothesis H1-3 was also supported, as BL students demonstrated significantly better practical skills compared to TL students. The substantial impact of blended learning on students' application abilities can be attributed to the opportunities for hands-on practice and experimentation that BL environments provide. Virtual simulations, online laboratories, and other digital tools in blended settings offer students interactive experiences that aid in mastering practical skills (Antonelli et al., 2023). For instance, combining offline and virtual experiments have been shown to improve student performance by enabling faster knowledge acquisition and exploration (Kerimbayev et al., 2023). Virtual laboratories offer safe, interactive platforms for students to observe phenomena that may not be possible in physical settings (Seifan et al., 2020). These immersive environments, along with enhanced communication and teamwork facilitated by blended learning, promote collaboration, knowledge sharing, and innovative problem-solving (Li & Cao, 2020). Furthermore, Liu et al. (2021) found that a blended model incorporating computer-assisted self-study, group discussion, and simulation training significantly improved students' practical application skills.

Overall, the findings suggest that blended learning positively impacts students' ability to apply knowledge in practical contexts, fostering the development of essential operational skills through enriched learning environments and collaborative opportunities.

Students' Deep Learning Perception

The research findings robustly support hypotheses H2-1, H2-2, H2-3, and H2-4, indicating that students in the BL group had significantly higher perceptions across the four dimensions of higher-order cognition, interactive learning, reflective learning, and emotional experience compared to their TL counterparts. This is consistent with previous studies showing that CoI-based blended courses facilitate deeper learning (Tabassum & Mohd Saad, 2024; Zhang, 2020).

For hypothesis H2-1, the results indicated that BL students exhibited significantly better perceptions in the higher-order cognitive dimension. This finding highlights the model's effectiveness in promoting engagement in advanced learning activities, such as application, analysis, evaluation, and creation. Yaniawati et al. (2022) similarly observed significant improvements in students' creative thinking and problem-solving skills within mobile-based blended learning environments. The intelligent pedagogy framework, which integrates various learning approaches, also showed enhanced higher-order thinking capabilities among students (Meng & Zhang, 2020). Notably, during the COVID-19 pandemic, blended learning became a normative approach that effectively supported higher-order thinking skills. Well-designed blended learning models leverage both online and offline modalities, enhancing cognitive abilities and fostering deeper engagement in learning activities.

In terms of hypothesis H2-2, BL students reported significantly higher perceptions of interactive learning. This can be attributed to the flexible nature of online components within blended courses, which provided opportunities for interaction and allowed students to engage with in-depth discussions at their own pace (Wut et al., 2022). Castro (2019) emphasized the role of innovative technologies in facilitating effective student interaction in higher education blended learning. Enhanced interactive opportunities in blended learning environments improve communication, collaboration, and knowledge sharing, thereby enriching students' cognitive and interactive capabilities (Islam et al., 2022).

Regarding hypothesis H2-3, the BL group exhibited enhanced reflective learning perceptions, suggesting improved recognition of learning challenges and engagement in reflective practices. This improvement may stem from the facilitated problem presentation and discussion typical of blended environments, which foster self-regulation and reflection (Bizami et al., 2023; Wu et al., 2023). Zhu and Bonk (2019) noted that feedback mechanisms and reflective questions significantly promote self-monitoring and reflection. Additionally, real-time technology-supported interactions likely motivate learners and enhance engagement, thereby improving reflective practices and overall learning quality (Zhu et al., 2021).

For hypothesis H2-4, the BL group demonstrated superior perceptions of emotional experiences, with a moderate effect size, indicating the positive impact of blended learning on the affective domain. This enhancement can be linked to personalized learning interventions that improve students' attitudes, motivation, and self-efficacy (Zhang et al., 2020). Ballouk et al. (2022) highlighted the role of teaching guidance in fostering active learning and motivation in blended environments. A supportive, user-friendly blended learning context—augmented by accessible digital tools—transforms students' perceptions of learning, leading to positive emotional experiences (Masadeh, 2021). The availability of diverse learning resources, such as quizzes and case studies, further enhances self-efficacy (Prifti, 2022). Consequently, blended learning environments shift away from traditional teaching paradigms, providing enriched emotional experiences that contribute to improved learning outcomes.

Conclusions

This study examined the effectiveness of a Community of Inquiry (CoI)-based blended learning model implemented through an intelligent learning platform, revealing significant improvements in both students' learning outcomes and their deep learning perceptions. These findings affirm the model's efficacy. Educators designing such models should capitalize on the strengths of both online and offline learning to foster robust teaching, social, and cognitive presences. Using digital resources enhances students' access to information and supports creative learning. Additionally, providing targeted guidance through online platforms can facilitate student reflection on their learning strategies and outcomes. Incorporating both online and offline discussions fosters a more engaging and satisfying interactive learning experience, enhancing emotional engagement.

These insights are valuable for future AI-driven blended course design, underscoring the importance of strategically integrating online and offline components to optimize learning outcomes. The effectiveness of CoI-based blended learning models in promoting deep learning among college students is clearly demonstrated. However, several limitations warrant consideration. First, the sample comprised sophomores from specific educational technology classes at a university in southern China, which limits the generalizability of the findings. Second, the instructional design requirements may differ for courses outside Digital Film and Television Directing and Production, meaning the proposed model's effectiveness could vary across courses and disciplines. Third, the CoI-based blended learning model was only compared to traditional learning; its efficacy against other blended models remains to be explored.

Future research could address these limitations by expanding the sample to include learners from various majors and courses. Comparative analyses could assess the differential impacts of blended learning across different disciplines. Additionally, investigating the relationship between students' sense of presence, learning effectiveness, and deep learning perceptions in blended environments would provide deeper insights into the mechanisms that contribute to successful blended learning experiences. Furthermore, future research should examine the implementation differences between the CoI framework in traditional blended learning and AI-driven distance education. Specifically, exploring how AI technologies can collaborate with the CoI framework to optimize instructional design, enhance student engagement, and improve personalized learning experiences will be a key area of future investigation. In conclusion, while this study highlights the benefits of CoI-based blended learning, future research should aim to address its limitations and explore the broader applicability and underlying mechanisms that enhance blended learning effectiveness.

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