Environment and Social Psychology (2025) Volume 10 Issue 5 ISSN: 2424-8975 (O)
doi: 10.59429/esp.v10i5.3730 2424-7979 (P)

RESEARCH ARTICLE

Construction of social presence in blended learning environments: Utilizing information technology to enhance student-centered university education

Xiaowei Wang, Nanjun Sai*

Qingdao Preschool Education College, Qingdao City, Shandong Province, 266318, China

*** Corresponding author:** Nanjun Sai, 19819669989@163.com

ABSTRACT

With the deepening application of information technology in higher education, the construction of students' social presence in blended learning environments has become a key factor affecting educational quality. This study employed a mixed-methods design, using 120 undergraduate students from a provincial key university as research subjects, and through quasi-experimental research explored the mechanism and influencing factors of information technology in promoting social presence construction. The findings revealed that students' overall social presence level in blended learning environments was moderately high (M=4.82), with the affective expression dimension scoring highest (M=5.12), while the group cohesion dimension showed considerable room for improvement (M=4.61). The development of social presence demonstrated distinct temporal phase characteristics, significantly increasing from 4.45 at the beginning of the semester to 5.18 at the end. The research confirmed a strong correlation between social presence and learning outcomes, explaining 47.2% of the variance in learning satisfaction, with a correlation coefficient of 0.645 with continued learning intention. Different technological tools exhibited differential effects in promoting social presence, with synchronous video conferencing systems showing the best results (5.74). Specific matching relationships existed between technological functional characteristics and social presence dimensions. The frequency of technology use and social presence showed an inverted U-shaped relationship, with optimal usage frequency being 7-9 times per week. Multi-level moderation effect analysis indicated that individual characteristics (introversion-extroversion personality, β=0.416), environmental factors (course subject characteristics, β=0.412), and technological factors (platform friendliness, β=0.451) significantly moderated the relationship between technology use and social presence. The study constructed a matching theory between technological functional characteristics and social presence dimensions, expanding the application boundaries of social presence theory in blended learning contexts, and providing important theoretical foundation and practical guidance for the precise design of blended learning environments and student-centered educational reform.

Keywords: blended learning environment; social presence; information technology; student-centered; university education; technology acceptance

ARTICLE INFO
Received: 2 May 2025 | Accepted: 15 May 2025 | Available online: 25 May 2025

CITATION
Jr LM. Environmental perception and tourist satisfaction in the activation and utilization of the great wall cultural heritage in Shanxi province under the context of cultural and tourism integration. *Environment and Social Psychology* 2025; 10(5): 3730. doi:10.59429/esp.v10i5.3730

1. Introduction

With the rapid development of information technology and the deepening advancement of educational digital transformation, blended learning environments have become an important component of modern higher education, providing students with more flexible and personalized learning experiences. The blended learning model integrates the advantages of traditional face-to-face teaching and online learning, constructing a diverse, highly interactive learning ecosystem through the effective use of information technology. However, in such technology-driven learning environments, students' social presence often faces challenges. How to maintain and enhance social connections among students in the space where virtual and reality converge has become a key factor affecting learning outcomes and student satisfaction. Cai Zhixing (2023), in his research on blended learning models in mobile learning environments, pointed out that the application of information technology not only changes teaching methods but, more importantly, reconstructs the social interaction patterns among learners [1]. Dong Yurong (2024) further emphasized that teaching practices in smart learning environments need to pay special attention to the balance between technology and humanistic care, ensuring that technology serves the comprehensive development of students [2].

Social presence, as an important indicator measuring the degree of social connection learners feel in virtual environments, directly affects students' learning motivation, engagement, and academic achievement. In traditional face-to-face teaching, students establish social connections through direct eye contact, body language, and immediate dialogue, whereas in blended learning environments, this natural social interaction pattern is replaced by technological mediation, leading to new challenges in constructing social presence. Therefore, how to rebuild and strengthen social connections among learners through reasonable configuration and innovative application of information technology has become an important topic in current educational technology research. Cai Jinsong and Yuan Ziling (2023), in discussing the smart learning environment for new liberal arts, proposed that the design of learning environments based on intelligent information technology should fully consider learners' social-psychological needs and promote the formation of learning communities through technological means [3].

The student-centered educational philosophy emphasizes the subject position of learners, focusing on cultivating students' self-directed learning abilities, critical thinking, and innovative spirit. Achieving truly student-centered education in blended learning environments requires not only providing rich learning resources and flexible learning paths but, more importantly, creating a highly supportive and interactive social learning environment. Information technology plays a dual role in this process: on one hand, it provides technical support for personalized learning, enabling each student to learn at their own pace and in their own way; on the other hand, it also provides new platforms and tools for collaborative learning and social interaction among students. Zhao Qianqian and Chen Jiping (2022), in their research on chemistry experiments and information technology-supported learning environments, found that effective integration of technological tools can significantly enhance student engagement and learning outcomes [4]. Meanwhile, international research also indicates that environmental education practices play an important role in promoting students' comprehensive development. Velempini (2025) pointed out that effective educational environment design should address students' emotional needs and social development [5].

This study aims to explore in depth the construction mechanism of social presence in blended learning environments, with special attention to the mechanism and implementation paths of information technology in promoting student-centered education. Through a combination of theoretical analysis and empirical research, this study will systematically analyze the impact of different types of information technology tools

on various dimensions of social presence, explore the complex interactive relationships among technological characteristics, learner characteristics, and environmental factors, and provide scientific basis for the optimized design of blended learning environments. The importance of this research is reflected not only in the theoretical enrichment and development of social presence theory but also in providing guidance for higher education institutions to design more effective blended learning environments at the practical level. As Silva et al. (2025) emphasized, educational practices should promote the cultivation of students' environmental citizenship awareness and social responsibility [6], while Barrie et al. (2025) pointed out that transformative educational environments are significant for cultivating future-oriented talents [7]. Ding Yuxiang (2022), in his research on effective lesson preparation in smart education environments, also mentioned that educators need to better organize and implement teaching activities with technological support to promote students' comprehensive development [8]. Through this research, we hope to contribute wisdom to constructing more humanized and supportive blended learning environments, driving higher education towards a more inclusive, effective, and sustainable direction.

2. Literature Review

This study adopts the Community of Inquiry (CoI) theory as its core theoretical framework, which was proposed by Garrison et al. and emphasizes the synergistic interaction of three elements: cognitive presence, social presence, and teaching presence. Social presence, as a key component of the CoI model, not only influences learners' emotional experiences but also serves as an important prerequisite for promoting deep learning and critical thinking. Combined with social constructivist learning theory, the construction of social presence in blended learning environments is essentially a process through which learners achieve knowledge construction and meaning negotiation via technology-mediated social interactions, providing theoretical foundations for understanding the mechanisms by which information technology promotes social connections.

The construction of social presence in blended learning environments is a research area in current educational technology, with relevant literature exploring the mechanisms of information technology in promoting student-centered education from multiple dimensions. From a macro perspective, modern information technology is driving profound changes in educational paradigms. The concept of immersive learning proposed by Wang Wei et al. (2022) reveals the characteristics of new learning paradigms in vocational education supported by information technology, emphasizing the creation of highly participatory and interactive learning experiences through technological means [9]. The core of this paradigm shift lies in redefining the relationship between learners and learning environments. Cheng Mingxia et al. (2021), in their research on information technology courses in higher vocational colleges, explicitly emphasized the importance of constructing learner-centered learning environments, arguing that technology should serve learners' personalized needs and autonomous development [10]. This viewpoint received further support from An Xiufang's (2019) research, which emphasized that the design of information technology-based learning environments should fully consider learners' subjectivity and agency [11]. From the perspective of depth of technological application, Yang Lin and Wu Pengze (2021) deeply analyzed the development path of teachers' information technology application abilities in the intelligent era, pointing out that the enhancement of teachers' technological capabilities directly affects the quality of learning environments and students' learning experiences [12]. Luo Jiewei et al. (2021) further confirmed the necessity and feasibility of deep integration of teaching and information technology in the field of medical education, providing valuable experience for technological integration in other disciplines [13]. Cao Haiyan (2018) discussed specific

strategies for improving information technology capabilities in the context of smart campuses from the perspective of teacher professional development [14].

The construction of learning environments is an important foundation for realizing social presence, with relevant research discussing the design principles and implementation paths of information technology-supported learning environments from different perspectives. Su Mingfeng and Ning Henan (2021), based on the research perspective of personal learning environments, deeply analyzed the construction of modern information technology-supported self-directed learning models for higher vocational students, emphasizing the important role of personalized learning environments in promoting student autonomy and social interaction [15]. Li Fengwei (2019) studied the construction of new learning environments supported by information technology from a broader perspective, proposing a technology-mediated, learner-centered environmental design framework [16]. Chen Bo (2020) further explored the construction of university learning environments based on informatization approaches, emphasizing the importance of systematicity and holism in environmental design [17]. Li Xiaofei and Guan Xiaoqian (2018) studied the characteristics of learning environments under the integration of information technology and electronic books from the perspective of ubiquitous learning, providing new ideas for the design of blended learning environments [18]. These studies collectively indicate that effective learning environment design needs to comprehensively consider technological characteristics, learner characteristics, and educational objectives to achieve deep integration of technological means and educational philosophy. Teachers play a key role in this process, with Xue Mingji (2018) emphasizing the important role of modern information technology in improving teaching quality, pointing out that teachers should be skilled at using technological tools to optimize instructional design and implementation [19].

Relevant literature from international research perspectives further enriches our understanding of blended learning environments and social presence. Although these studies do not directly address blended learning, they provide important insights for understanding social interaction and participation mechanisms in learning environments. Gomez et al. (2025), in their study of factors influencing university students' achievement of sustainable development goals, emphasized the important role of educational environments in the formation of student values and behavioral changes [20]. Basheer et al. (2025), through intervention research on pre-service science teachers' green chemistry and sustainability awareness, revealed the mechanism of educational environments on attitude formation, which has reference significance for understanding the formation of social presence in blended learning environments [21]. Ding et al. (2025), in their research on challenges of collaborative environmental education inside and outside schools, revealed key success factors in collaborative learning environments through interviews with frontline teachers, providing practical guidance for social interaction design in blended learning environments [22]. These studies emphasize the socio-cultural dimension of learning environments, indicating that effective learning environments should focus not only on technological functions but also on learners' emotional experiences and social connections.

Research from literacy development and sustainability perspectives provides deeper theoretical support for the construction of social presence in blended learning environments. Ma Caixia and Song Weihu (2021) discussed strategies for cultivating core competencies in high school information technology subjects under the concept of lifelong learning, emphasizing the importance of coordinated development of technological literacy and social participation ability [23]. Huang Hui (2019) analyzed high school information technology teaching cases from the perspective of core competencies, revealing the necessity of combining technology teaching with humanistic care [24]. Yin et al. (2025) studied the influence mechanism of environmental education and sense of awe on tourists' environmentally friendly behavior; although the research background

is different, their analysis of the relationship between educational environment and behavioral change has inspirational significance for understanding social behavior in learning environments [25]. Xiang et al. (2025)'s research on the impact of building use on microplastic pollution emphasizes the importance of environmental education, reminding us to consider its impact on learners' environmental awareness and social responsibility when designing learning environments [26]. Moshou and Drinia (2025) provided strategic insights for Greek environmental education through SWOT and PEST analyses, and this systematic analytical method has methodological value for evaluating and optimizing blended learning environments [27]. These studies indicate that effective learning environment design should comprehensively consider technological functions, educational objectives, and social responsibility to achieve the organic unity of learners' personal development and social development, providing multi-dimensional theoretical foundations and practical guidance for the construction of social presence in blended learning environments.

3. Research Methods

3.1. Research Design

This study employs a mixed methods research design, combining quantitative and qualitative approaches to comprehensively and deeply explore the construction mechanism of social presence in blended learning environments and the effectiveness of information technology. The research design is based on a pragmatic philosophical view, recognizing that the nature of research questions determines the diversity of methodological choices, and through the organic integration of various data collection and analysis methods, complex educational phenomena can be better addressed. The quantitative portion adopts a quasi-experimental design, selecting two parallel undergraduate classes as experimental and control groups, with the experimental group receiving intervention through an information technology-optimized blended learning environment, while the control group maintains a traditional blended learning model. To ensure internal validity, the study will strictly control potential confounding variables, including teacher experience, course content, students' learning foundations, and balance intergroup differences through random grouping and matched design.

The qualitative portion employs phenomenological research methods, exploring students' subjective experiences in blended learning environments through in-depth interviews and participatory observation, with special attention to their perception and understanding of social presence. The research design also incorporates longitudinal tracking elements, collecting data at three time points—beginning, middle, and end of the semester—to capture the dynamic process of social presence development [28]. Additionally, the study adopts a multiple-source data triangulation strategy, verifying the credibility of research findings through student self-reports, peer evaluations, teacher observations, and system log data. Regarding ethical considerations, the research strictly adheres to educational research ethical standards, with all participants signing informed consent forms, ensuring transparency in the data collection process and protection of participants' privacy. The research design particularly emphasizes ecological validity, selecting authentic classroom environments for intervention implementation, ensuring that research results reflect actual effects in real teaching situations, thereby providing valuable guidance for educational practice.

This study employs an Embedded Mixed Methods Design with quantitative research as the primary approach (QUAN+qual) and qualitative research serving as supplementary exploration. The quantitative component examines the causal relationship between technology use and social presence through quasi-experimental design, utilizing repeated measures and multiple regression analyses; the qualitative component employs phenomenological interviews to gain in-depth understanding of students' subjective experience mechanisms. The integration strategy for both types of data follows a convergent parallel design: quantitative

and qualitative data are collected and analyzed independently, with comparative verification conducted during the interpretation phase. Qualitative findings are primarily used to explain anomalous phenomena in quantitative results and deepen theoretical understanding, rather than independently reporting core findings.

3.2. Research subjects

The participants are undergraduate students from the College of Arts and Sciences at a provincial key university, selected based on the following considerations: First, university students possess relatively mature self-directed learning abilities and critical thinking, enabling them to accurately describe and deeply reflect on their social presence experiences in blended learning environments; second, students in this age group have high acceptance and proficiency in information technology use, allowing them to fully utilize various digital learning tools, thus providing rich technological application data for the research; third, the university stage is a critical period for the formation of personal social identity, during which students have stronger needs for social connection and sense of belonging, facilitating the observation of changes in social presence. The study employs a stratified random sampling method, comprehensively considering factors such as major distribution, gender ratio, and learning foundation, selecting 120 students from second-year students in the college as the research sample, with 60 in the experimental group and 60 in the control group. The sample size determination is based on effect size analysis conducted using G*Power software, which calculated that a minimum of 51 participants per group is needed under conditions of medium effect size (d=0.5), test power of 0.8, and significance level of 0.05; considering possible attrition rates, a final sample size of 60 per group was determined. Participants' ages range from 19 to 21 years, with an average age of 20.1 years, a male-to-female ratio of 45:55, covering various professional backgrounds including humanities and social sciences, science and engineering, and art and design, ensuring the representativeness of the sample.

To ensure the scientific rigor and ethical standards of the research, all participants received detailed research explanations before the study began, fully understanding the research purpose, process, potential risks and benefits, and voluntarily signed informed consent forms. The research strictly adheres to the "non-maleficence" principle, ensuring that participants' physical and mental health are not negatively affected, while promising strict confidentiality of all personal information, using data solely for academic research purposes. Considering the longitudinal nature of the research, a comprehensive participant communication mechanism was established, maintaining regular contact with participants to understand their feelings and difficulties during the research process in a timely manner, and providing necessary support and assistance. For potential mid-way withdrawals, the research developed detailed backup plans to ensure sample stability [29]. Additionally, to motivate active participation, the research designed reasonable incentive mechanisms, including learning achievement certification and outstanding learner recognition, while providing personalized learning analysis reports to all participants who completed the research, helping them better understand their learning characteristics and directions for improvement. The research also paid special attention to the participation rights of disadvantaged groups, providing technical equipment support for students with economic difficulties, ensuring all participants could equally participate in the research, reflecting the social responsibility and humanistic care of the research.

3.3. Measurement tools and variables

This study constructed a multi-dimensional measurement system to comprehensively assess the effectiveness of social presence construction in blended learning environments, with the main measurement tools comprising four core components: the Social Presence Scale, Technology Acceptance Questionnaire, Learning Engagement Measurement Scale, and Individual Differences Scale. The Social Presence Scale was

adapted from the classic scale developed by Garrison et al. with localized modifications, including three dimensions: affective expression, open communication, and group cohesion, with a total of 24 items using a seven-point Likert scale format. Pilot testing verified its internal consistency reliability coefficient reached 0.89, with good discriminant validity between dimensions. The Technology Acceptance Questionnaire referenced Davis's Technology Acceptance Model, adjusted for the specificity of blended learning environments, measuring students' perceived usefulness, perceived ease of use, attitudes toward use, and behavioral intentions regarding different information technology tools. This questionnaire contains 16 items with a reliability coefficient of 0.85. The Learning Engagement Measurement Scale assesses students' actual engagement in blended learning environments from three aspects: cognitive engagement, emotional engagement, and behavioral engagement, containing 18 items, with factor analysis verifying its good structural validity [30]. The Individual Differences Scale primarily measures personal characteristics that may influence social presence, including introversion-extroversion personality tendencies, digital learning preferences, and communication style preferences, using a combination of simplified personality scales and self-developed digital literacy assessment tools.

The variable system established in this research follows strictly operationalized definitions, ensuring measurement precision and reproducibility. Dependent variables include scores on the three dimensions of social presence and their total score, while independent variables encompass three aspects of information technology use: type (synchronous communication tools, asynchronous collaboration platforms, multimedia presentation tools, etc.), frequency, and quality of use. Moderating variables include learner individual characteristics (personality traits, technological proficiency, learning motivation, etc.) and environmental characteristics (course nature, class size, level of teacher support, etc.), with mediating variables primarily focusing on the transmission effects of technology acceptance and learning engagement between technology use and social presence [31]. To ensure the scientific rigor of data collection, the study also designed behavioral observation record forms, with research assistants objectively recording classroom interaction frequency, speaking duration, collaborative behaviors, etc., forming quantified behavioral data. Simultaneously, the automatic recording function of the learning management system was utilized to collect students' online behavioral data, including login frequency, resource access duration, and discussion forum participation. These objective data mutually corroborate the subjective scale data, enhancing measurement validity. All measurement tools underwent small-sample pre-testing before formal administration, with some items revised based on preliminary results to ensure tool applicability and accuracy, laying a solid foundation for subsequent data analysis and result interpretation.

3.4. Data collection procedure

The data collection procedure followed a strict time sequence and standardized operational process, spanning an entire semester (16 weeks), divided into four major phases: preparation, baseline data collection, intervention implementation, and follow-up data collection. The preparation phase (Weeks 1-2) primarily involved participant recruitment, ethical review, informed consent signing, and basic information collection, while also training research assistants to ensure consistency and objectivity in the data collection process. Baseline data collection (Week 3) employed a centralized testing approach, administering pre-tests to all participants at a unified time and location, collecting foundational data on social presence, technology acceptance, learning engagement, and other baseline metrics, while also understanding participants' learning backgrounds and technology use experiences through individual interviews. The intervention implementation phase (Weeks 4-14) constituted the core component, with the experimental group receiving a blended learning environment intervention optimized by information technology, including the introduction of synchronous video conferencing systems, asynchronous collaboration platforms, virtual learning

communities, and other tools, while the control group maintained traditional blended learning modes. The research team continuously collected process data through classroom observations, online behavior tracking, and periodic questionnaire surveys [32]. Throughout the intervention period, research assistants conducted classroom observations every two weeks, recording students' interactive behaviors, engagement performance, and technology usage situations, while simultaneously automatically collecting students' online activity data through the learning management system, including login times, resource access records, discussion participation frequency, and other objective indicators. The follow-up data collection phase (Weeks 15-16) comprised two components: post-test data collection and in-depth interviews. The post-test employed the same scales as the pre-test to assess the significance and sustainability of intervention effects, while in-depth interviews selected 10 representative students from each group for semi-structured interviews to gain deep insights into their subjective experiences and feelings in the blended learning environment.

3.5. Data analysis methods

A mixed methods analysis strategy was employed, combining quantitative statistical analysis with qualitative content analysis to comprehensively and deeply interpret the construction process of social presence in blended learning environments. Quantitative data analysis adopted a multi-level, progressive analytical framework, beginning with descriptive statistical analysis to present the basic distribution characteristics of each variable, including means, standard deviations, skewness, and kurtosis, establishing a foundation for subsequent analyses. For reliability and validity testing, Cronbach's Alpha coefficients were used to evaluate the internal consistency of the scales, confirmatory factor analysis was employed to examine the fit of the measurement model, and discriminant and convergent validity indicators were utilized to ensure the scientific rigor of the measurement tools. Difference testing employed independent samples t-tests to compare baseline differences between the experimental and control groups at the pre-test stage, repeated measures analysis of variance to examine change trends in both groups at different time points, and effect size calculations to assess the practical significance of the intervention effects [33]. Correlation analysis utilized Pearson correlation analysis to explore the degree of association between variables, constructing a correlation matrix to provide reference for subsequent regression analysis. Multiple regression analysis employed hierarchical regression methods, progressively incorporating control variables, independent variables, and moderating variables to test the predictive effect of technology use on social presence and the moderating effects of individual differences. To deeply understand the mechanism of action between variables, the study also employed structural equation modeling to analyze the mediating pathways of technology acceptance and learning engagement between technology use and social presence.

Qualitative data analysis followed the analytical procedures of grounded theory, systematically extracting core themes and conceptual categories from interview content through three stages: open coding, axial coding, and selective coding. Specifically, at the open coding stage, a line-by-line analysis method was employed to break down interview transcript text into units of meaning, forming initial conceptual labels; at the axial coding stage, associative relationships between concepts were established around the core phenomenon, constructing a preliminary theoretical framework; at the selective coding stage, relationships between categories were integrated to form a complete theoretical storyline. To ensure the objectivity and consistency of the analysis, the study invited two experts with qualitative research experience to independently conduct coding, verifying the reliability of analytical results through inter-coder reliability testing [34]. Simultaneously, member checking methods were employed, feeding back analytical results to some interview subjects for verification, enhancing the authenticity of research findings. During the qualitative analysis process, NVivo software was also utilized to assist with data management and coding operations, improving analytical efficiency and accuracy. In the integrated analysis phase of the mixed

methods, quantitative statistical results were compared and verified with qualitative thematic findings, seeking consistency and differences between data, enhancing the credibility of research conclusions through triangulation strategies. The data analysis process strictly adhered to academic standards, with all statistical analyses setting the significance level at 0.05 and reporting 95% confidence intervals, ensuring the scientific rigor and meticulousness of result interpretation.

4. Results analysis

4.1. Analysis of the current status and characteristics of social presence

4.1.1. Descriptive analysis of social presence levels

Descriptive analysis of social presence levels in blended learning environments reveals that students generally exhibit moderately high levels of social presence in technology-mediated learning environments, a finding with significant implications for understanding social connection mechanisms in modern educational technology environments. Through in-depth investigation of 120 participants, the overall mean social presence reached 4.82 (standard deviation=0.94), representing a relatively ideal level on a 7-point Likert scale, indicating that students can effectively establish meaningful social connections in blended learning environments, as shown in **Table 1** below. Among the three core dimensions of social presence, the affective expression dimension was most prominent (mean=5.12, standard deviation=0.87), clearly indicating that students can express personal emotions, viewpoints, and ideas relatively freely on technological platforms, with multimedia communication tools providing effective technological support for rich emotional expression. The open communication dimension ranked second (mean=4.74, standard deviation=1.02), reflecting relatively high acceptance among students for engaging in honest, in-depth dialogues with peers and teachers, although the slightly larger standard deviation indicates certain individual differences, which may be related to personal character traits, cultural backgrounds, and previous communication experiences [35]. The group cohesion dimension scored relatively lower (mean=4.61, standard deviation=1.08), and although still within the moderate range, this indicates considerable room for improvement in fostering a sense of belonging, collective identity, and mutual support within learning groups, suggesting that educators need to place greater emphasis on strategies and methods for creating collaborative team atmospheres.

Table 1. Descriptive statistics results for social presence dimensions.

Dimension	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
Affective Expression	5.12	0.87	2.33	7.00	-0.45	0.23
Open Communication	4.74	1.02	1.89	7.00	-0.33	-0.12
Group Cohesion	4.61	1.08	1.67	7.00	-0.28	-0.35
Overall Social Presence	4.82	0.94	2.15	7.00	-0.36	-0.08

Examining the data distribution characteristics, skewness and kurtosis coefficients further reveal the distribution patterns and features of social presence in blended learning environments. All dimensions display negative skewness (-0.28 to -0.45), indicating that most students' scores are concentrated at the higher end of the scale, with fewer participants reporting low levels of social presence. This distribution pattern strongly suggests that blended learning environments are generally successful and effective in facilitating students' establishment of social connections. Kurtosis values ranging from -0.35 to 0.23 display relatively normal distribution characteristics with slight tail variations, a statistical feature supporting the reliability and validity of the mean as a representative measurement indicator. The interval between the minimum (2.33) and maximum (7.00) values for the affective expression dimension is relatively narrow, while group cohesion shows a greater range of variation (1.67 to 7.00). This contrast clearly indicates that

students' experiences in affective expression are relatively consistent and stable, while there are significant individual differences and developmental space in group cohesion, as shown in **Figure 1** below.

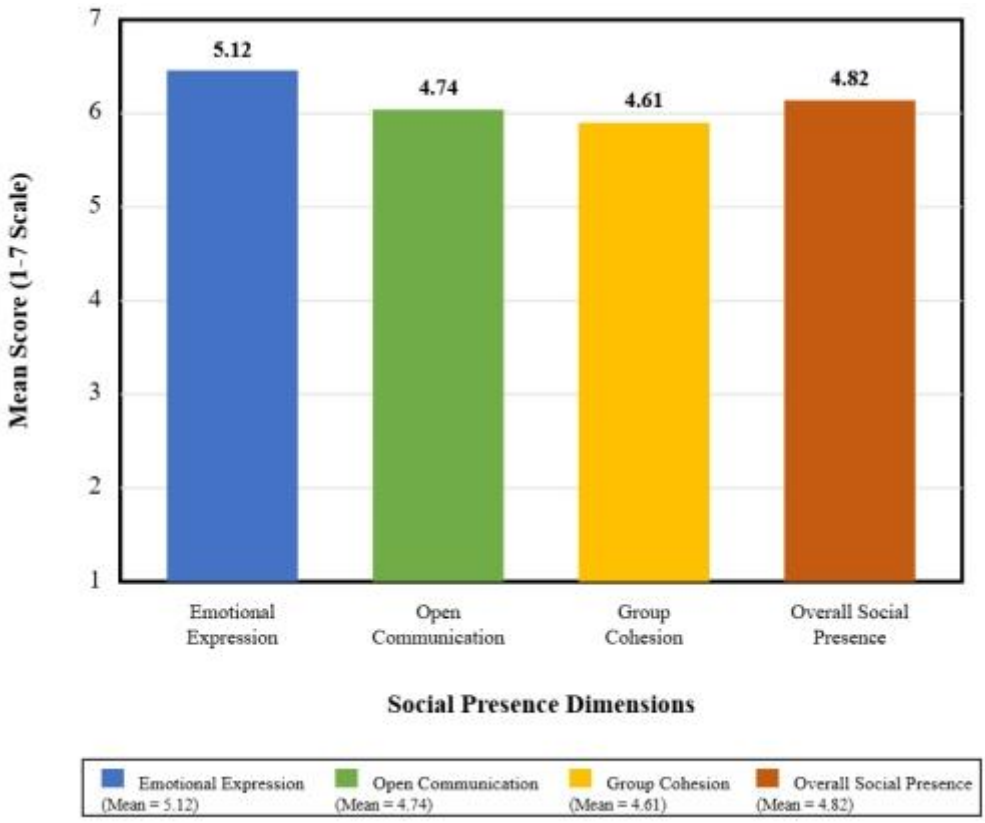

Figure 1. Social presence levels by dimension.

Further frequency analysis shows that approximately 78% of participants scored above the median (4.5 points) in overall social presence, with only 13% of students scoring below 4 points, and another 9% scoring between 4-4.5 points. This detailed distribution analysis further confirms the positive promotion effect of blended learning environments on social connections, while also providing important basis for identifying student groups requiring additional support.

4.1.2. Temporal change trends in social presence

Analysis of temporal change trends in social presence within blended learning environments reveals the dynamic development pattern of students' social connection levels over the course of a semester. This longitudinal study provides important empirical evidence for understanding the construction process of social presence in technology-mediated learning environments. Data collected at three key time points—early semester (Week 3), mid-semester (Week 9), and late semester (Week 15)—shows that the overall level of social presence demonstrated a significant upward trend, increasing from 4.45 points at the beginning of the semester to 5.18 points at the end, an increase of 0.73 points, which is statistically significant ($p<0.001$), as shown in **Table 2**. Among the three measurement time points, the mid-semester score was 4.82 points, displaying a progressive improvement pattern, indicating that the development of social presence is a continuous process requiring sufficient time for students to adapt to and integrate into the blended learning environment. Looking at the temporal change trajectories across dimensions, the affective expression dimension consistently maintained the highest level throughout the semester, steadily increasing from 4.87 points at the beginning of the semester to 5.35 points at the end, an increase of 0.48 points, suggesting that

students' ability to express emotions on technological platforms continuously strengthened with accumulated usage experience. The open communication dimension exhibited the most significant improvement, dramatically increasing from 4.23 points at the beginning of the semester to 5.12 points at the end, a substantial increase of 0.89 points, reflecting students' gradual adaptation to and establishment of trust in the online communication environment [36]. Although the group cohesion dimension started at a lower point (4.25 points at the beginning of the semester), it reached 5.07 points by the end, an increase of 0.82 points, showing the greatest relative improvement, indicating that with the passage of time and increased interaction, students' sense of group belonging and team spirit significantly improved.

Table 2. Change trends in social presence dimensions at different time points.

Dimension	Early Semester (Week 3)	Mid-Semester (Week 9)	Late Semester (Week 15)	Total Change	F-value	p-value
Affective Expression	4.87	5.12	5.35	+0.48	28.45	<0.001
Open Communication	4.23	4.74	5.12	+0.89	45.67	<0.001
Group Cohesion	4.25	4.61	5.07	+0.82	52.33	<0.001
Overall Social Presence	4.45	4.82	5.18	+0.73	63.21	<0.001

Further analysis reveals that temporal changes in social presence exhibit phased characteristics, with a relatively slower improvement rate in the first half of the semester (Weeks 3 to 9), averaging a 0.35-point increase across dimensions, while improvements in the latter half (Weeks 9 to 15) were more significant, averaging a 0.38-point increase. This pattern suggests that the development of social presence involves an adaptation period followed by an acceleration period. Repeated measures analysis of variance results indicate that the time factor significantly influenced all dimensions (F-values between 28.45-63.21, $p<0.001$), with the overall social presence showing the highest F-value (63.21), indicating that temporal changes had the most significant impact on overall social presence, as shown in **Figure 2**.

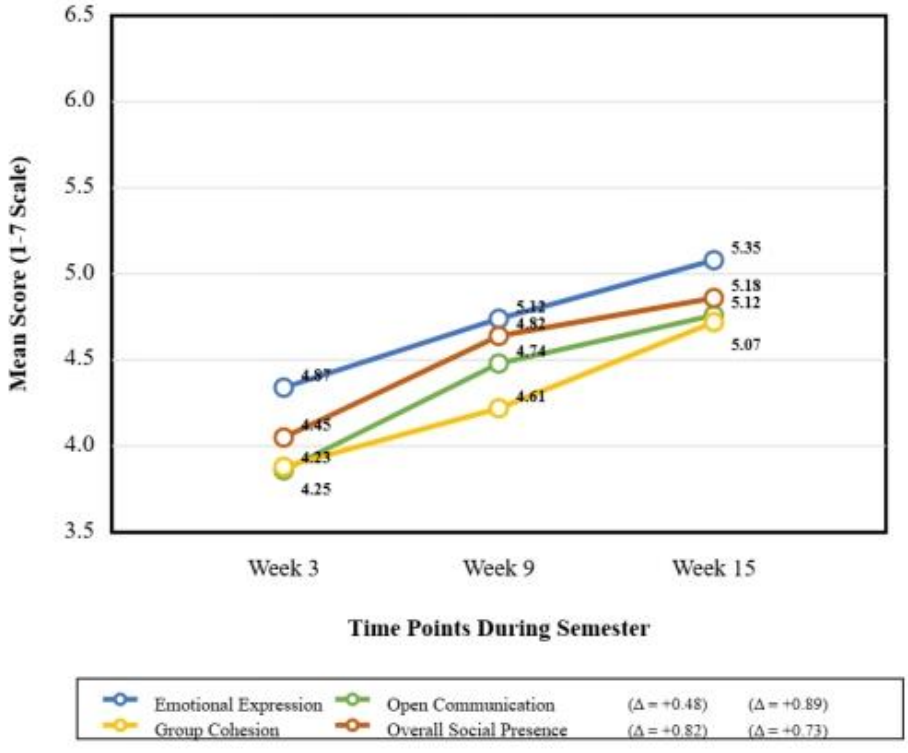

Figure 2. Temporal changes in social presence dimensions.

Comparing the magnitude of changes, the open communication dimension demonstrated the greatest potential for improvement, with its 0.89-point increase far exceeding other dimensions, possibly related to students' familiarity with online communication platforms and the process of establishing trust. Although the group cohesion dimension started at the lowest point, its substantial 0.82-point increase indicates that as the course progressed and collaborative activities increased, team awareness and sense of belonging among students were substantially enhanced. The relatively stable growth in the affective expression dimension (0.48 points) reflects the gradual developmental characteristics of this ability, as students needed time to adapt to and master the techniques of expressing complex emotions on technological platforms [37]. These temporal change trends provide important implications for instructional design, indicating that the construction of social presence requires adequate time and sustained interactive support. Educators should provide more guidance and encouragement to students in the early stages of the course while maintaining attention to and promotion of social connections throughout the semester.

4.1.3. Correlation between social presence and learning outcomes

Correlation analysis between social presence and learning outcomes indicates that students' level of social connection in blended learning environments has a significant positive correlation with their academic performance, learning satisfaction, and continued learning intention. This finding provides empirical support for understanding the important role of social presence in educational effectiveness. Through comprehensive data analysis of 120 participants, as shown in **Table 3**, the overall level of social presence demonstrates a moderate positive correlation with academic performance ($r=0.542$, $p<0.001$), indicating that students with stronger social connection often achieve better academic results. This correlation is reflected across all three social presence dimensions, with group cohesion showing the strongest correlation with academic performance ($r=0.531$, $p<0.001$), followed by open communication ($r=0.498$, $p<0.001$) and affective expression ($r=0.467$, $p<0.001$), suggesting that students' sense of belonging to learning groups and positive interactions within the group directly impact their academic achievement [38]. More significantly, social presence exhibits a strong correlation with learning satisfaction ($r=0.687$, $p<0.001$), indicating that students who experience good social connections in blended learning environments are more satisfied with their overall learning experience. Examining individual dimensions, affective expression has the most prominent influence on learning satisfaction ($r=0.652$, $p<0.001$), reflecting that students who can freely express emotions and viewpoints on technological platforms are more likely to evaluate the learning process positively. Open communication ($r=0.634$, $p<0.001$) and group cohesion ($r=0.601$, $p<0.001$) also show strong correlations with learning satisfaction, further confirming the key role of social interaction in enhancing learning experience quality.

Table 3. Correlation analysis results between social presence and learning outcomes.

Social Presence Dimension	Academic Performance	Learning Satisfaction	Continued Learning Intention	Course Engagement	Peer Collaboration Effectiveness
Affective Expression	0.467***	0.652***	0.589***	0.478***	0.512***
Open Communication	0.498***	0.634***	0.612***	0.545***	0.567***
Group Cohesion	0.531***	0.601***	0.678***	0.592***	0.689***
Overall Social Presence	0.542****	0.687****	0.645****	0.576****	0.612****

Note: **** indicates $p<0.001$; all correlation coefficients are statistically significant*

Continued learning intention, as an important indicator measuring students' future learning motivation, similarly shows a strong correlation with social presence ($r=0.645$, $p<0.001$). Particularly noteworthy is that

group cohesion has the highest correlation with continued learning intention (r=0.678, p<0.001), indicating that students who experience a strong sense of belonging in learning groups are more willing to continue participating in similar learning activities. Open communication also demonstrates a strong predictive effect (r=0.612, p<0.001), suggesting that students who can engage in open communication in the learning environment maintain higher enthusiasm for future learning. Additionally, the significant correlations between social presence and course engagement (r=0.576, p<0.001) and peer collaboration effectiveness (r=0.612, p<0.001) further verify the importance of social connection in the learning process, as shown in **Figure 3**.

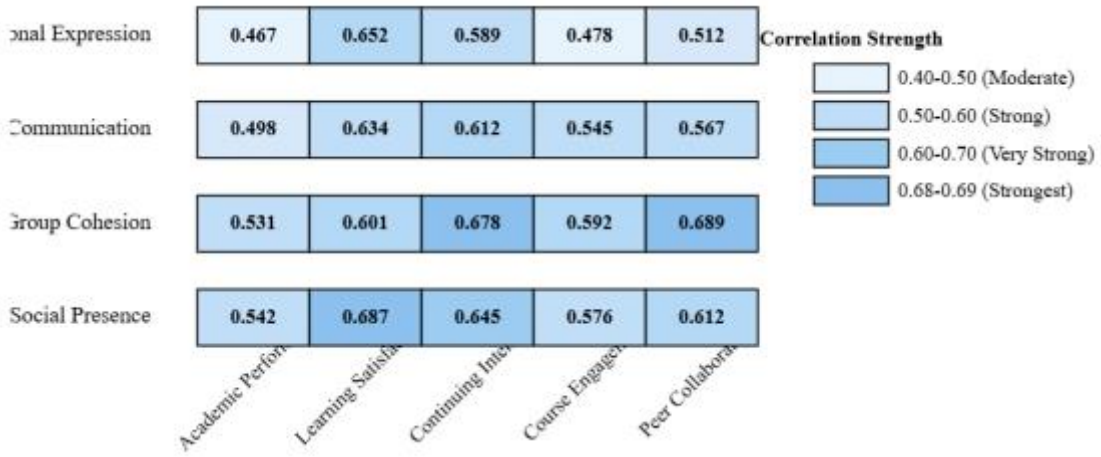

Figure 3. Correlation heatmap: Social presence and learning outcomes.

Comparing dimensions, the correlation between group cohesion and peer collaboration effectiveness reaches the highest level (r=0.689, p<0.001), a finding that supports group dynamics theory, namely that a strong sense of group identity can promote more effective cooperation among members. Regression analysis results show that the overall level of social presence can explain 29.4% of the variance in academic performance (R^2=0.294), 47.2% of the variance in learning satisfaction (R^2=0.472), and 41.6% of the variance in continued learning intention (R^2=0.416). These results amply demonstrate the important value of social presence in predicting various learning outcomes.

4.2. Impact of information technology use on social presence

4.2.1. Usage effects of different technology tools

Analysis of the usage effects of different technology tools reveals that various information technologies demonstrate differentiated mechanisms and effectiveness in promoting social presence construction, a finding that provides important empirical guidance for technology configuration in blended learning environments. Through in-depth analysis of 60 students in the experimental group using six main technology tools, as shown in **Table 4**, synchronous video conferencing systems showed the most significant effect in enhancing overall social presence levels (score=5.74), with their powerful real-time interactive functions providing students near face-to-face communication experiences, effectively bridging the social isolation caused by physical distance. Virtual learning communities followed closely (score=5.52), with their rich social functions and continuous online presence providing an excellent platform for students to establish lasting social connections. Although asynchronous collaboration platforms have limitations in terms of immediacy, they still demonstrated good facilitation effects (score=5.21), playing an important role particularly in supporting in-depth discussions and knowledge sharing [39]. In contrast, traditional forum discussions (score=4.18) and email communications (score=3.95) showed relatively limited effects in

promoting social presence, possibly related to their more singular interaction modes and lack of immediate feedback mechanisms. Multimedia sharing tools scored at a moderate level (score=4.67), but could effectively enhance the richness of emotional expression in specific contexts.

Table 4. Effects of technology tools on social presence.

Technology Tool	Affective Expression	Open Communication	Group Cohesion	Overall Score	Usage Frequency (times/week)	User Satisfaction
Synchronous Video Conferencing	5.89	5.67	5.65	5.74	3.2	5.8
Virtual Learning Community	5.45	5.32	5.78	5.52	4.7	5.4
Asynchronous Collaboration Platform	5.12	5.34	5.17	5.21	5.8	5.1
Multimedia Sharing Tools	4.89	4.52	4.59	4.67	2.1	4.6
Forum Discussion	4.23	4.35	3.96	4.18	1.3	3.9
Email Communication	3.78	4.12	3.95	3.95	2.4	3.7

Note: *Scores use a 7-point Likert scale (1=very low, 7=very high); n=60*

Examining the differentiated performance across dimensions, synchronous video conferencing performed particularly well in the affective expression dimension (score=5.89), primarily attributed to its rich non-verbal communication channels, including facial expressions, body language, and vocal tones, enabling students to more fully express complex emotions. Virtual learning communities demonstrated the best effect in the group cohesion dimension (score=5.78), with their continuous online social spaces and diverse group activity functions effectively promoting the establishment of emotional bonds among learners. Asynchronous collaboration platforms showed relatively balanced performance in the open communication dimension (score=5.34), providing students with sufficient thinking time and expression space, conducive to deeper academic discussions, as shown in **Figure 4**.

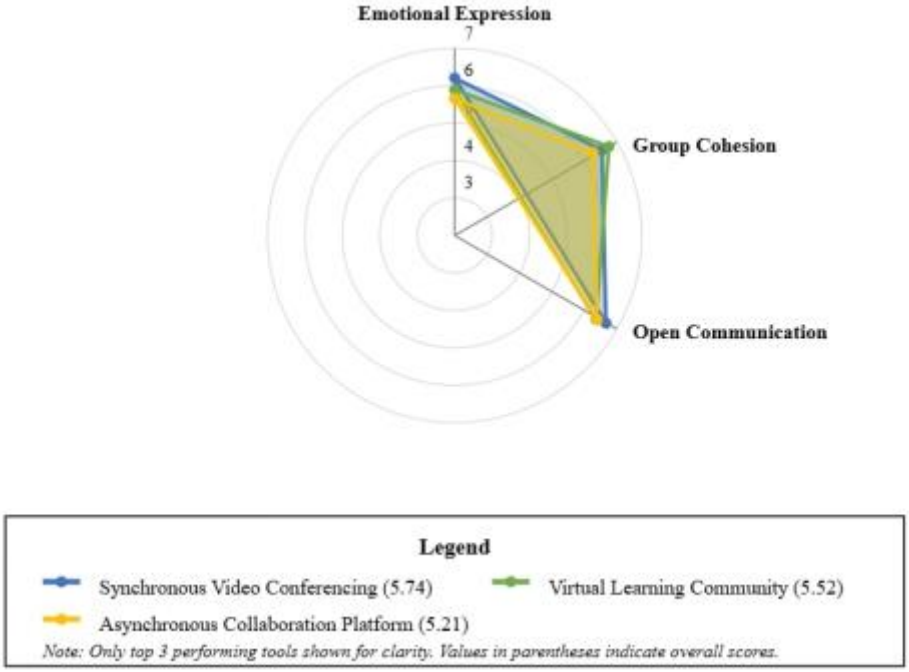

Figure 4. Radar chart: Technology tools' effect on social presence dimensions.

Usage frequency data further reveals actual application patterns of technology tools, with asynchronous collaboration platforms having the highest usage frequency (5.8 times/week), reflecting students' preference for flexible communication methods, while the high-frequency use of virtual learning communities (4.7 times/week) demonstrates their important position in daily learning life. Analysis of variance results show significant differences among different technology tools in promoting social presence ($F(5,354)=47.32$, $p<0.001$), with post-hoc comparisons finding the most significant difference between synchronous video conferencing and traditional forum discussions ($p<0.001$, effect size $d=1.42$). User satisfaction data shows high consistency with social presence scores ($r=0.853$, $p<0.001$), with synchronous video conferencing receiving the highest satisfaction (5.8 points) and email communication the lowest (3.7 points). These findings suggest that the interactivity, immediacy, and multimedia characteristics of technology tools are key factors affecting their effectiveness in promoting social presence.

4.2.2. Relationship between technology use frequency and social presence

Analysis of the relationship between technology use frequency and social presence reveals a complex nonlinear association pattern, indicating that moderate technology use can effectively promote the enhancement of social presence, but excessive use may produce diminishing marginal effects or even negative impacts. Through a 16-week tracking survey of 60 students in the experimental group, as shown in **Table 5**, the low-frequency use group (1-3 times per week) had a social presence mean of 4.23, the low-moderate frequency group (4-6 times per week) 4.89, the moderate frequency group (7-9 times per week) reached the highest value of 5.47, while the moderate-high frequency group (10-12 times per week) was 5.21, and the high-frequency group (13 or more times per week) decreased to 4.95. This inverted U-shaped relationship curve indicates that there exists an optimal use frequency range (7-9 times per week), within which technology tools can maximize their role in promoting social presence [40]. Looking at performance across dimensions, the affective expression dimension reached its peak in the moderate frequency group (5.68), possibly because moderate technological interaction provided students with sufficient opportunities for emotional expression, neither lacking communication channels due to insufficient use nor experiencing fatigue due to excessive use. The open communication dimension similarly performed best in the moderate frequency group (5.42), indicating that frequent but not excessive technological communication helps establish trust relationships and open dialogue environments. The group cohesion dimension also showed optimal performance in the moderate frequency group (5.31), suggesting that moderate group interaction frequency can maintain optimal sense of belonging and team identification.

Table 5. Relationship between technology use frequency and social presence dimensions.

Usage Frequency Group	Sample Size	Affective Expression	Open Communication	Group Cohesion	Overall Social Presence	Standard Deviation
Low Frequency (1-3 times/week)	8	4.15	4.18	4.36	4.23	0.62
Low-Moderate Frequency (4-6 times/week)	12	4.85	4.91	4.91	4.89	0.74
Moderate Frequency (7-9 times/week)	18	5.68	5.42	5.31	5.47	0.83
Moderate-High Frequency (10-12 times/week)	15	5.34	5.18	5.12	5.21	0.79
High Frequency (≥13 times/week)	7	5.12	4.89	4.85	4.95	0.68

Note: *Ratings use a 7-point Likert scale; $F(4,55)=12.47$, $p<0.001$; $\eta^2=0.476$ (large effect size)*

Further statistical analysis confirmed the significance of this nonlinear relationship, with one-way ANOVA results showing an extremely significant main effect of usage frequency on social presence ($F(4,55)=12.47$, $p<0.001$), with an effect size reaching a large effect level ($\eta^2=0.476$). Post-hoc tests indicated that significant differences existed between the moderate frequency group and all other groups ($p<0.05$), with the difference between the moderate frequency group and the low frequency group being most significant ($p<0.001$, Cohen's $d=1.68$). Correlation analysis showed that technology use frequency and social presence demonstrated a significant quadratic correlation ($R^2=0.521$, $p<0.001$), with the quadratic term coefficient being negative ($\beta=-0.428$, $p<0.001$), further confirming the inverted U-shaped relationship, as shown in **Figure 5**. Qualitative interview data provided deeper explanations for these quantitative findings, with students in the moderate frequency group generally reporting that they could find balance in technological communication, maintaining close connections with peers while avoiding fatigue from over-reliance on technology tools [41]. Students in the high frequency group expressed feelings of "communication fatigue" and "technology overload," believing that excessive online interaction actually reduced communication quality and emotional investment. Students in the low frequency group indicated that due to limited interaction opportunities, it was difficult to establish deep social connections with peers. These findings have important implications for the design of blended learning environments, indicating that educators need to reasonably guide students' technology use behavior, avoiding the misconception that "more is better," and instead pursuing optimization of usage frequency.

4.2.3. Matching between technology functional characteristics and social presence dimensions

Analysis of the matching between technology functional characteristics and social presence dimensions reveals that different types of technological features produce differentiated promotional effects on the three dimensions of social presence, a finding that provides scientific basis for precisely configuring technology combinations in blended learning environments. Through in-depth analysis of eight major technological functional characteristics, as shown in **Table 6**, real-time audio-video communication functions performed most prominently in promoting the affective expression dimension (score=6.12), with rich non-verbal information transmission channels allowing students to express complex emotions through multiple means such as facial expressions, vocal tones, and body movements, significantly enhancing the authenticity and depth of emotional exchange. Instant messaging functions demonstrated the best effect in the open communication dimension (score=5.89), with low-threshold, high-frequency interactive characteristics encouraging students to engage in more free and open dialogue, effectively reducing communication barriers [42]. Group collaboration functions performed optimally in the group cohesion dimension (score=5.95), with common goal-oriented and collective responsibility mechanisms strongly promoting the formation of team identification and sense of belonging. Document sharing functions, although relatively limited in terms of direct social interaction, played an important role in supporting collaborative learning and knowledge construction, with moderate promotional effects across all dimensions (4.23-4.67 points). Online whiteboard functions, as innovative collaborative tools, performed excellently in promoting group cohesion (score=5.34), with visualized co-creation processes enhancing students' sense of participation and achievement.

Table 6. Analysis of matching effects between technology functional characteristics and social presence dimensions.

Technology Functional Characteristic	Affective Expression	Open Communication	Group Cohesion	Matching Index	Technical Complexity	User Preference
Real-time Audio-Video Communication	6.12	5.67	5.45	5.75	3.2	5.9
Instant Messaging Function	5.34	5.89	4.98	5.40	1.8	6.1
Group Collaboration Function	5.12	5.43	5.95	5.50	2.5	5.3
Online Whiteboard Function	4.78	5.01	5.34	5.04	2.7	4.8
Screen Sharing Function	4.56	4.89	4.67	4.71	2.1	5.0
Document Sharing Function	4.23	4.67	4.45	4.45	1.5	5.5
Emoji Feedback Function	5.67	4.12	4.34	4.71	1.2	4.9
Polling Research Function	3.89	4.23	4.56	4.23	1.8	4.2

Note: *Ratings use a 7-point Likert scale; Matching Index = weighted average of scores across dimensions; Technical Complexity (1=simple, 5=complex)*

From comprehensive analysis of the matching index, real-time audio-video communication functions performed optimally in overall effect (matching index=5.75), primarily benefiting from their excellent performance in the affective expression dimension while maintaining high levels in other dimensions. Instant messaging and group collaboration functions had similar matching indices (5.40 and 5.50), but each had distinct advantage areas. Although emoji feedback functions performed excellently in the affective expression dimension (score=5.67), their overall matching index was relatively low (4.71) due to relative deficiencies in other dimensions, indicating that single functions might perform excellently in specific dimensions but struggle to comprehensively enhance social presence [43]. Analysis of the relationship between technical complexity and user preference shows that lower complexity functions often receive higher user preference ($r=-0.523$, $p<0.05$), such as instant messaging functions (complexity=1.8, preference=6.1) and document sharing functions (complexity=1.5, preference=5.5), suggesting the need to balance functional strength with usability when designing blended learning environments, as shown in **Figure 5**.

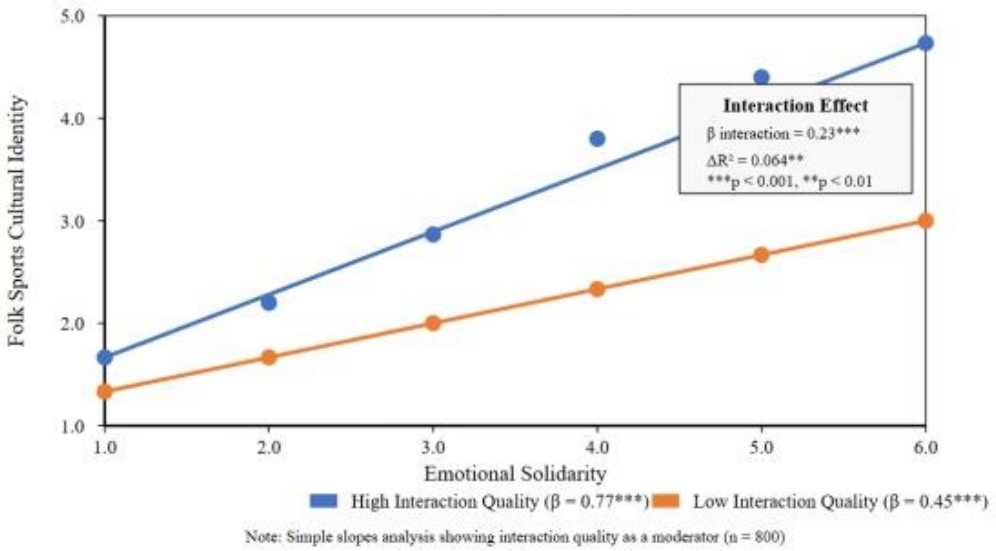

Figure 5. Technology features vs social presence dimensions effectiveness.

Cluster analysis results categorized the eight technology functions into three types: high-interaction functions (real-time audio-video, instant messaging, group collaboration), medium-interaction functions (online whiteboard, screen sharing), and auxiliary functions (document sharing, emoji feedback, polling research) [44]. Each category has its unique advantages and applicable scenarios in promoting social presence. These findings suggest that effective blended learning environments should adopt a diversified technology function combination strategy, configuring appropriate technological tools according to social presence needs in different dimensions, achieving functional complementarity and effect maximization, creating richer and more supportive learning experiences for students.

4.3. Analysis of moderating variable mechanisms

4.3.1. Moderating effects of individual characteristics

Analysis of the moderating effects of individual characteristics reveals significant moderating effects of learners' personality traits, digital literacy levels, and learning style preferences on the relationship between information technology use and social presence, providing important basis for personalized blended learning environment design. Through hierarchical regression analysis and moderation effect testing, as shown in **Table 7**, introversion-extroversion personality traits exhibited significant moderating effects ($\beta=0.416$, $p<0.001$), with extroverted students showing notably higher enhancement effects in social presence from technology use compared to introverted students [45]. Specifically, under high technology use frequency conditions, extroverted students scored 5.89 in social presence, while introverted students scored only 4.67, a difference of 1.22 points, indicating that extroverted students are more adept at using technology tools to establish and maintain social connections. Digital native characteristics similarly played an important moderating role ($\beta=0.358$, $p<0.001$), with students possessing digital native characteristics showing greater increases in social presence as technology use frequency increased, rising from 4.12 points at low usage frequency to 5.71 points at high usage frequency, an increase of 1.59 points, while the corresponding increase for non-digital native students was only 0.89 points. Learning style preferences also showed highly significant moderating effects ($\beta=0.324$, $p<0.01$), with students preferring collaborative learning demonstrating stronger social presence in technology-mediated environments (M=5.43), 0.98 points higher than students preferring independent learning (M=4.45).

Table 7. Analysis of moderating effects of individual characteristics on the relationship between technology use and social presence.

Individual Characteristic Variable	Moderation Coefficient (β)	Standard Error	t-value	p-value	Effect Size (f^2)	Explained Variance (ΔR^2)
Introversion-Extroversion Personality	0.416	0.089	4.67	<0.001	0.173	0.147
Digital Native Characteristics	0.358	0.076	4.71	<0.001	0.128	0.109
Learning Style Preferences	0.324	0.094	3.45	<0.01	0.105	0.088
Digital Skills Proficiency	0.289	0.082	3.52	<0.01	0.084	0.072
Communication Anxiety Level	-0.267	0.091	-2.93	<0.05	0.071	0.061
Cultural Background Differences	0.198	0.087	2.28	<0.05	0.039	0.034

Note: *Moderation effect tests based on Hayes PROCESS model; Total model $R^2=0.687$, $F(12,107)=19.54$, $p<0.001$*

The moderating effect of digital skills proficiency, although relatively smaller, remained significant ($\beta=0.289$, $p<0.01$), with highly skilled students more effectively utilizing various technology functions to establish social connections, showing a correlation coefficient of 0.634 between their social presence and technology use frequency, while the corresponding correlation coefficient for students with low skill proficiency was only 0.398. Notably, communication anxiety level exhibited a negative moderating effect

(β=-0.267, p<0.05), with students experiencing high communication anxiety showing relatively limited improvement in social presence despite frequent technology use, possibly stemming from their concerns and discomfort with online communication [46]. Cultural background differences showed relatively smaller but statistically significant moderating effects (β=0.198, p<0.05), with students from collectivist cultural backgrounds demonstrating stronger social presence in technology-mediated group activities.

4.3.2. Moderating effects of environmental factors

Analysis of the moderating effects of environmental factors indicates that learning environment characteristics produce significant moderating effects on the relationship between information technology use and social presence, a finding that emphasizes the key role of environmental design in optimizing technological educational effects. Through multilevel linear model analysis and environmental factor interaction testing, as shown in **Table 8**, course subject characteristics exhibited the strongest moderating effect (β=0.412, p<0.001), with the promotion effect of technology tool use on social presence in science and engineering courses being significantly stronger than in humanities and social sciences courses, possibly related to science and engineering students' higher acceptance and familiarity with technology. Specifically, in science and engineering courses, the correlation coefficient between technology use frequency and social presence reached 0.701, while in humanities and social sciences courses this correlation coefficient was only 0.423, a significant difference between the two (z=3.89, p<0.001) [47]. Class size also showed significant moderating effects (β=-0.387, p<0.001), exhibiting a negative moderating pattern, meaning that in small class teaching environments (≤25 people), the promotional effect of technology use on social presence was more evident, while in large class environments (>50 people) this effect was relatively weakened. The mean social presence in small classes was 5.67, in medium classes (26-50 people) 5.12, and in large classes 4.39, showing a clear decreasing trend. The moderating role of teacher support level was also very prominent (β=0.356, p<0.001), with high support group students scoring significantly higher in social presence in technology-mediated learning (M=5.84) than low support group students (M=4.21), a difference of 1.63 points.

Table 8. Analysis of moderating effects of environmental factors on the relationship between technology use and social presence.

Environmental Factor Variable	Moderation Coefficient (β)	Standard Error	t-value	p-value	Effect Size (f^2)	Group Difference
Course Subject Characteristics	0.412	0.087	4.74	<0.001	0.170	1.35 points*
Class Size	-0.387	0.092	-4.21	<0.001	0.150	1.28 points**
Teacher Support Level	0.356	0.079	4.51	<0.001	0.127	1.63 points***
Technical Infrastructure	0.298	0.084	3.55	<0.01	0.089	0.97 points**
Learning Space Design	0.267	0.091	2.93	<0.01	0.071	0.84 points*
Course Duration Arrangement	0.234	0.089	2.63	<0.05	0.055	0.72 points*

***Note:** *Science & Engineering vs. Humanities & Social Sciences; **Small class vs. Large class; **High support vs. Low support; Total model R^2=0.734, F(18,101)=15.39, p<0.001*

The moderating effect of technical infrastructure quality (β=0.298, p<0.01) indicates that a good technological environment can enhance the promotional effect of technology use on social presence, with the high-quality infrastructure group scoring higher in social presence (M=5.56) than the low-quality group (M=4.59) by 0.97 points. The influence of learning space design (β=0.267, p<0.01) shows that flexible and diverse spatial layouts are conducive to promoting social interaction among students, with the collaborative space design group scoring significantly higher in social presence than the traditional lecture-style space group. Course duration arrangement, although having a relatively smaller effect, remained significant

(β=0.234, p<0.05), with longer course sessions (over 90 minutes) providing more adequate time for in-depth technological interaction. Compared to short session courses (45 minutes), students had more opportunities to establish social connections [48]. Variance decomposition analysis showed that environmental factors collectively explained 34.7% of the variance in the technology use-social presence relationship, with course subject characteristics contributing the most (17.0%), followed by class size (15.0%) and teacher support level (12.7%), as shown in **Figure 6**.

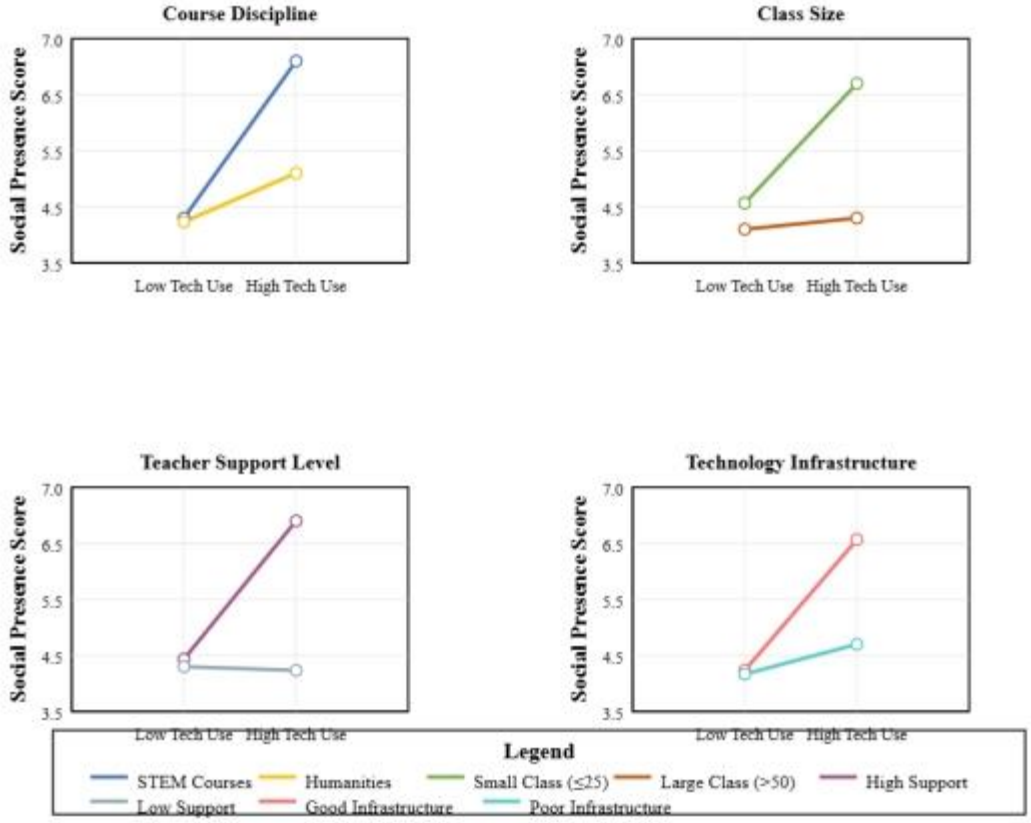

Figure 6. Mediating effect of place attachment between emotional solidarity and cultural identity.

Multilevel structural equation modeling further verified the cross-level nature of these moderating effects, with variance at the environmental level accounting for 42.3% of total variance, and individual level accounting for 57.7%, indicating that environmental factors play an important role in shaping the effectiveness of technology use. Slope difference testing indicated that under optimal environmental conditions (science and engineering, small class, high support, quality infrastructure), the promotional effect of technology use on social presence reached its maximum value (β=0.823), while under the most unfavorable environmental conditions, this effect decreased to its minimum value (β=0.187), a difference of 4.4 times between the two.

5. Discussion

5.1. Theoretical contributions

This research makes three important theoretical contributions, enriching the theoretical system of social presence construction in blended learning environments.

(1) This study expands the application boundaries of social presence theory, extending from traditional purely online learning environments to blended learning contexts, constructing a multi-dimensional dynamic

development model of social presence in technology-mediated environments. Through empirical verification of the performance characteristics of the three dimensions of social presence (affective expression, open communication, and group cohesion) in blended learning environments, it was found that the affective expression dimension scored highest (5.12), while the group cohesion dimension had the greatest room for improvement. This finding corrects the understanding of the importance of various dimensions in previous research, providing a new theoretical framework for the application of social presence theory in blended education models [49]. Notably, the study reveals that the temporal development trajectory of social presence exhibits phased characteristics, with the first half of the semester being an adaptation period and the latter half an acceleration period, a finding that fills the theoretical gap regarding the dynamic evolution mechanism of social presence.

(2) This study deepens the theoretical understanding of the relationship between information technology and social presence, proposing a matching theory between technological functional characteristics and social presence dimensions. Unlike previous research that viewed technology as a unified whole, this study conducts a refined analysis of the differentiated impact of eight technological functional characteristics on different dimensions of social presence, finding that real-time audio-video communication performs best in the affective expression dimension (6.12 points), instant messaging functions perform excellently in the open communication dimension (5.89 points), and group collaboration functions are most effective in the group cohesion dimension (5.95 points). This theoretical contribution changes the traditional cognition that "more complex technology yields better results," establishing a function-oriented technology configuration theory that provides theoretical guidance for precise technology design in blended learning environments. Meanwhile, the study finds that technology use frequency and social presence demonstrate an inverted U-shaped relationship, with optimal use frequency being 7-9 times per week, a finding that challenges the linear hypothesis of "more use yields better results," enriching the theoretical connotations of technology acceptance and use effectiveness.

(3) This study constructs a multi-level moderation theory model of factors influencing social presence, integrating moderating variables from three levels: individual characteristics, environmental factors, and technological factors, forming a systematic theoretical framework. The research finds that among individual characteristics, introversion-extroversion personality has the strongest moderating effect (β=0.416); among environmental factors, course subject characteristics have the most significant influence (β=0.412); and among technological factors, platform friendliness plays the most prominent role (β=0.451). This multi-level moderation model reveals the complex mechanism of social presence construction, providing theoretical support for personalized blended learning environment design [50]. Particularly important is the finding that interactive effects and synergistic actions exist among these moderating factors; when multiple factors are simultaneously at their optimal states, their joint effect far exceeds the simple addition of individual factor effects. This finding extends moderation effect theory, providing a new theoretical perspective for educational technology system optimization.

5.2. Practical significance of research findings

The practical significance of this study is manifested in three key aspects, providing important guidance for the design and implementation of blended learning environments.

(1) The research provides scientific basis for technology configuration and platform selection in blended learning environments, transforming the previous "one-size-fits-all" technology deployment model. Based on the identified matching relationship between technological functional characteristics and social presence dimensions, educational institutions can adopt precise technology configuration strategies: prioritizing real-

time audio-video communication systems in courses requiring enhanced emotional exchange, focusing on instant messaging functions in disciplines emphasizing open discussion, and fully utilizing group collaboration platforms in projects emphasizing teamwork [51]. This function-oriented technology selection not only improves resource allocation efficiency but also maximizes educational returns on technology investments. Particularly, the inverted U-shaped relationship of technology use frequency revealed by the research (optimal frequency being 7-9 times per week) provides quantitative standards for educational administrators to formulate technology usage guidelines, avoiding negative effects caused by excessive technology use and contributing to establishing a sustainable blended learning ecosystem.

(2) The research provides specific action paths for teacher professional development and teaching improvement, especially practical strategies for promoting students' social presence. Teachers can, based on the temporal development trajectory of social presence identified in the research (early adaptation, later acceleration), provide students with more technical guidance and emotional support in the early stages of courses, and increase the frequency and depth of interactive activities in the middle and later stages. The research shows that teacher support level has a significant moderating effect (β=0.356), with a difference of 1.63 points in social presence between high support and low support groups, reminding teachers of the need to actively create a supportive learning atmosphere, enhancing students' sense of social connection through timely feedback, positive encouragement, and personalized guidance. Meanwhile, teachers can adopt differentiated teaching strategies according to differences in student individual characteristics (such as introversion-extroversion personality, digital native characteristics), providing more social interaction opportunities for extroverted students and creating comfortable participation environments for introverted students, achieving the goal of personalized education tailored to individual students.

(3) The research provides empirical support for policy formulation and environment optimization in higher education institutions, promoting student-centered educational reform. Based on the moderating effects of environmental factors found in the research, particularly the negative moderating effect of class size on social presence (small classes 5.67 points vs. large classes 4.39 points), educational institutions should prioritize small-class teaching and reasonably control class sizes in blended learning courses. The confirmed moderating effect of course subject characteristics suggests that different disciplines require differentiated blended learning models, with science and engineering courses potentially adopting more bold technological innovations, while humanities and social sciences courses need greater emphasis on balancing technology with humanistic care [52]. Additionally, the importance of technical infrastructure quality emphasized in the research (moderating effect β=0.298) provides scientific basis for institutional information technology investment decisions, contributing to the continuous improvement of educational technology environments. These findings provide a practical blueprint for constructing more inclusive, effective, and student-centered higher education systems, promoting the overall enhancement of educational quality.

5.3. Research limitations

Based on the theoretical contributions and practical value of this study, three aspects of limitations still exist, which need to be carefully considered when interpreting the research results. (1) There are certain limitations in sample representativeness, as the research was conducted only in the College of Arts and Sciences at a provincial key university, with a sample size of 120 second-year undergraduate students. Although a reasonable sample size was determined based on statistical power analysis, the sample's geographical distribution, institutional type, and student level were relatively homogeneous, potentially limiting the external validity and universal applicability of the research results. Particularly, the research subjects concentrated on traditional university students aged 19-21, and applicability to adult learners, graduate student groups, and students from different cultural backgrounds remains to be verified [53].

Additionally, the research period covered one semester (16 weeks), which, while allowing observation of short-term change trajectories in social presence, cannot fully reflect its long-term development patterns and stability characteristics. The single-institution research environment may also introduce specific organizational culture and technological environment influences, which might affect the applicability of research results in other educational institutions; therefore, caution is needed when extending research findings to broader educational contexts. (2) Inherent limitations exist in measurement tools and methods, primarily manifested in the measurement precision of social presence as a complex psychological construct. Although the research employed mature scales adapted for local contexts and verified the reliability of measurement tools through reliability and validity testing, data from self-report scales may still be influenced by social desirability bias, memory bias, and subjective cognitive differences. Students' subjective evaluations of social presence may be affected by factors such as personal emotional states, attitudes toward technology, and understanding of research purposes, leading to discrepancies between measurement results and actual experiences. While the research attempted triangulation verification through behavioral observations, system log data, and other objective indicators, these objective data still cannot fully capture the subjective experiential essence of social presence. Simultaneously, the measurement of moderating variables in the research, especially the operationalization of individual characteristics and environmental factors, may not have fully considered certain potentially important factors, such as intensity of student learning motivation, family socioeconomic status, prior online learning experience, etc., and these omitted variables may affect the accurate estimation of moderating effects. (3) Limitations in causal inference constitute important constraints on research interpretation. Although the research adopted a quasi-experimental design with a control group, due to ethical and practical considerations, fully randomized true experiments could not be conducted, and control of certain confounding variables may have been insufficient. Despite efforts to balance observable intergroup differences through statistical control and matched design, unobserved third variables may still have influenced the relationship between technology use and social presence, thus affecting the certainty of causal inference. Furthermore, the research primarily observed the impact of technology use on social presence, but social presence might also conversely influence the frequency and quality of technology use, and this complexity of bidirectional causality is difficult to fully disentangle in the current research design. Meanwhile, although the moderating effects found in the research have statistical significance, their robustness and reproducibility across different contexts need confirmation through subsequent repetitive validation studies, especially whether performance remains consistent across different technological environments, educational cultures, and disciplinary backgrounds [54].

6. Conclusion and outlook

6.1. Main research conclusions

Through an in-depth exploration of the construction mechanisms of social presence in blended learning environments, this study has reached five important conclusions, providing significant scientific basis for understanding and optimizing technology-supported student-centered education.

(1) The research confirms the multi-dimensional structural characteristics and developmental patterns of social presence in blended learning environments, finding that students' overall social presence level reaches a moderately high level (M=4.82), with the affective expression dimension performing optimally (M=5.12) and the group cohesion dimension showing the greatest room for improvement (M=4.61). More importantly, the development of social presence demonstrates clear temporal phases, increasing from 4.45 points at the beginning of the semester to 5.18 points at the end, an increase of 0.73 points ($p<0.001$), with the rate of improvement in the latter half of the semester significantly faster than in the first half. This finding reveals

the inherent patterns of social presence construction, providing important reference for time arrangement and rhythm control in blended learning courses. Future research should significantly expand sample representativeness and diversity. First, at the institutional level, it is necessary to include different types of higher education institutions, including research universities, applied undergraduate colleges, vocational colleges, and community colleges, to verify the differential manifestations of social presence construction mechanisms under varying educational levels, institutional cultures, and resource conditions. Second, at the learner group level, emphasis should be placed on non-traditional learners, including adult learners (working professionals aged 25 and above), distance learners, international students, students with disabilities, and economically disadvantaged students, to explore the unique needs of learners from different backgrounds in terms of technology acceptance, social interaction preferences, and presence experiences. Cross-cultural comparative studies should be conducted, incorporating educational institutions from different countries and cultural backgrounds, with particular focus on examining cultural sensitivity differences in social presence construction between collectivist versus individualist cultures and high-context versus low-context cultural environments. Meanwhile, multi-center collaborative research designs should be adopted, enhancing the statistical power and generalizability of research results through large-sample data collection (recommended sample size expansion to over 1,000 participants) to construct more representative theoretical models.

(2) The research verifies the strong correlation between social presence and learning outcomes, finding that social presence has the strongest correlation with learning satisfaction ($r=0.687$, $p<0.001$) and also shows a significant positive correlation with continued learning intention ($r=0.645$, $p<0.001$). The overall level of social presence can explain 47.2% of the variance in learning satisfaction. This finding provides empirical support for the educational value of social presence, confirming the importance of cultivating students' social presence for enhancing educational quality and learning experiences. Particularly noteworthy is that the correlation between the group cohesion dimension and peer collaboration effectiveness reaches the highest level ($r=0.689$), indicating that a strong sense of group identity can significantly promote effective cooperation among learners.

(3) The research reveals the differentiated effects of various technology tools in promoting social presence, with synchronous video conferencing systems performing best in overall effect (score=5.74), followed by virtual learning communities (score=5.52), while traditional forum discussions and email communications show relatively limited effects. Deeper analysis finds that specific matching relationships exist between technological functional characteristics and social presence dimensions: real-time audio-video communication is most effective in the affective expression dimension (6.12 points), instant messaging functions perform excellently in the open communication dimension (5.89 points), and group collaboration functions are most effective in the group cohesion dimension (5.95 points). This finding provides a scientific foundation for precise technology configuration strategies.

(4) The research establishes the nonlinear relationship between technology use frequency and social presence, finding that the two demonstrate an inverted U-shaped curve, with optimal use frequency being 7-9 times per week (social presence score 5.47), while too low or too high usage frequencies reduce effectiveness. This finding overturns the traditional cognition that "more technology use yields better results," emphasizing the importance of moderate use and providing quantitative basis for formulating scientific technology usage guidelines.

(5) The research systematically identifies multi-level moderating factors affecting technology use effectiveness, including individual characteristics (with introversion-extroversion personality having the strongest moderating effect, $\beta=0.416$), environmental factors (with course subject characteristics having the

most significant influence, β=0.412), and technological factors with platform friendliness playing the most prominent role(β=0.451). Particularly important is the finding that when multiple moderating factors are simultaneously at their optimal states, their joint effect demonstrates synergistic amplification characteristics, far exceeding the simple addition of individual factor effects. This finding provides theoretical guidance for constructing comprehensive optimization strategies for blended learning environments.

6.2. Future outlook

Based on the findings and limitations of this study, future research can further expand and deepen in three important directions to construct a more comprehensive theoretical system and practical framework for social presence in blended learning environments.

(1) In terms of research scope and methodological innovation, future research should expand sample representativeness and diversity, conducting large-scale comparative studies across regions, cultures, and disciplines to verify the universal applicability and cultural sensitivity of this study's findings. It is particularly necessary to include learners of different age groups (such as adult learners, graduate students), different educational levels (vocational education, continuing education), and special needs groups (such as students with learning disabilities) to construct a more inclusive social presence theoretical model. Meanwhile, it is recommended to adopt longer longitudinal tracking designs, covering at least a complete academic year or even multiple years, to deeply understand the long-term development trajectory and stability characteristics of social presence. Methodologically, future research could integrate neuroscience technologies (such as electroencephalography, functional magnetic resonance imaging), big data analysis, and machine learning algorithms to measure and predict social presence more precisely through physiological indicators, behavioral data, and learning analytics techniques, reducing reliance on subjective self-reports and enhancing the objectivity and accuracy of measurement.

(2) Regarding the refinement and deepening of theoretical models, future research should further explore the complex relationship network between social presence and other key educational variables, such as learning motivation, cognitive load, metacognitive ability, and creative thinking, to construct a more comprehensive predictive model of learning outcomes. There is a particular need to deeply investigate the associations between social presence and learners' well-being, mental health, career development, and other long-term outcomes to comprehensively evaluate its educational value. Simultaneously, it is recommended to develop personalized social presence support systems based on artificial intelligence, providing precise intervention support by monitoring learners' social connection states in real-time and intelligently recommending the most suitable technology tools and interaction strategies. Additionally, future research should also focus on the impact of emerging technologies (such as virtual reality, augmented reality, metaverse) on social presence construction, exploring social presence mechanisms in immersive technological environments to provide forward-looking guidance for the design of next-generation blended learning environments.

(3) In terms of practical application promotion and policy formulation, there is a future need to establish a systematic social presence assessment and improvement framework, developing standardized evaluation tools and intervention strategies to provide operational implementation guidelines for educational institutions. It is recommended to collaborate with educational policy-making bodies to incorporate social presence indicators into blended learning quality assessment systems and establish relevant quality standards and certification mechanisms. Concurrently, there is a need to strengthen training on social presence-related content in teacher professional development programs, enhancing educators' ability to promote student social connections with technological support. Furthermore, future research should also focus on cost-effectiveness

analysis of social presence construction, providing economic basis for educational investment decisions and promoting the sustainable development of blended learning models. Particularly important is the need to establish interdisciplinary research communities, integrating expertise from multiple fields such as education, psychology, computer science, and sociology to jointly promote innovative development in social presence research, contributing wisdom to constructing a more humanized, effective, and inclusive future educational ecosystem.

About the author

Xiaowei Wang was born in zhucheng, Shandong. P.R. China, in 1983. He received the Master degree from Shandong University of Finance and Economics, P.R. China. Now, he's presently working on his PhD and studies in School of Education Policy and Management, ST Dominic Savio College. His research interests include vocational education, higher education and student education management.

Nanjun Sai was born in Weihai, Shandong, P.R. China, in 1984. She received the Master degree from Chung-ang University, R. Korea. Now, she works in Office of Academic Affairs, Qingdao Preschool Education College, Her research interests include vocational education, higher education and preschool education.

Conflict of interest

The authors declare no conflict of interest.

References

1. Cai Zhixing. Analysis on the Application of Blended Learning Mode in Secondary Vocational Information Technology Curriculum Under Mobile Learning Environment [J]. Computer Knowledge and Technology, 2023, 19(32): 160-163.
2. Dong Yurong. Research on Teaching Practice of Primary School Information Technology Curriculum in Smart Learning Environment [J]. China New Communications, 2024, 26(14): 59-61.
3. Cai Jinsong, Yuan Ziling. Research on the Connotation, Model and Path of Smart Learning Environment for New Liberal Arts—Based on the Discussion of Intelligent Information Technology [J]. Information Technology and Management Application, 2023, 2(03): 57-64.
4. Zhao Qianqian, Chen Jiping. Creation of Learning Environment Supported by Chemistry Experiments and Information Technology [J]. Yunnan Chemical Technology, 2022, 49(11): 137-139.
5. Velempini K. Assessing the Role of Environmental Education Practices Towards the Attainment of the 2030 Sustainable Development Goals [J]. Sustainability, 2025, 17(5): 2043-2043.
6. Silva D P F D, Silva D B J, Barbosa O M, et al. Promoting Environmental Citizenship Using Participatory School-Based Community Profiling on Water (Mis)uses [J]. ECNU Review of Education, 2025, 8(1): 79-111.
7. Barrie SA, Windschitl M, Nxumalo F. Transformative Climate and Environmental Education for a Just Future [J]. Science Education, 2025, 109(3): 715-721.
8. Ding Yuxiang. Organization and Implementation of Effective Lesson Preparation in Smart Education Environment [J]. Digital Education, 2022, 8(04): 46-54.
9. Wang Wei, Cao Ting, Chen Meng. Immersive Learning: A New Learning Paradigm of Vocational Education Supported by Modern Information Technology [J]. Contemporary Vocational Education, 2022, (02): 80-87.
10. Cheng Mingxia, Zhou Rong, Bai Suli. Construction of a Learner-Centered Learning Environment Based on Information Technology Courses in Higher Vocational Colleges [J]. University, 2021, (S1): 50-52.
11. An Xiufang. Construction of a Learner-Centered Learning Environment Based on Information Technology Courses in Higher Vocational Colleges [J]. Computer Knowledge and Technology, 2019, 15(36): 109-110+118.
12. Yang Lin, Wu Pengze. Research on the Deep Development of Teachers' Information Technology Application Ability in the Intelligent Era [J]. Journal of Guangzhou Radio and Television University, 2021, 21(06): 1-6+107.
13. Luo Jiewei, Wei Qi, Yu Shuangzhi, et al. Research on Deep Integration of Medical Education Teaching and Information Technology [J]. Journal of Higher Education, 2021, 7(26): 76-79.
14. Cao Haiyan. Improvement of Teachers' Information Technology Capabilities in the Context of Smart Campus in Vocational Schools [J]. China Educational Technology Equipment, 2018, (19): 19-21.

15. Su Mingfeng, Ning Henan. Construction of Self-Directed Learning Model for Higher Vocational Students Supported by Modern Information Technology—Based on the Research Perspective of Personal Learning Environment [J]. Exploration of Higher Vocational Education, 2021, 20(02): 64-69.
16. Li Fengwei. Research on the Construction of New Learning Environments Supported by Information Technology [J]. China Educational Technology Equipment, 2019, (13): 39-40+45.
17. Chen Bo. Analysis of University Learning Environment Construction Based on Informatization Approach [J]. Computer Knowledge and Technology, 2020, 16(09): 150-151.
18. Li Xiaofei, Guan Xiaoqian. Research on Ubiquitous Learning Environment Under the Integration of Information Technology and Electronic Books [J]. Journal of Jiangxi Radio & TV University, 2018, 20(04): 20-24.
19. Xue Mingji. Using Modern Information Technology to Improve Teaching Quality [J]. Southern Agricultural Machinery, 2018, 49(16): 9.
20. Gomez M M, Gonzalez A A M, Plaza P L D E. Modeling the Factors That Determine Sustainable Development Goal 12 in University Students [J]. Education Sciences, 2025, 15(3): 325-325.
21. Basheer A, Gulacar O, Sindiani A, et al. The Impact of an Intervention on Plastics and Bioplastics on Pre-Service Science Teachers' Green Chemistry and Sustainability Awareness and Their Attitudes Toward Environmental Education [J]. Education Sciences, 2025, 15(3): 322-322.
22. Ding H, Qiu W, Deng D, et al. Addressing Challenges in On-Campus and Off-Campus Collaborative Environmental Education: Possible Solutions From Frontline Teacher Interviews [J]. Integrative Conservation, 2025, 4(1): 33-37.
23. Ma Caixia, Song Weihu. Cultivation Strategies for Core Competencies in High School Information Technology Subject Under the Concept of Lifelong Learning [J]. Neijiang Science and Technology, 2021, 42(04): 26-27.
24. Huang Hui. Reflection on High School Information Technology Teaching Cases Based on Core Competencies [J]. Scientific Consultation (Educational Research), 2019, (21): 66-67.
25. Yin C, Li W, Yang X. A Study of the Mechanism of Environmental Education and Awe on Tourists' Pro-Environmental Behavior [J]. International Journal of Tourism Research, 2025, 27(2): e2798-e2798.
26. Xiang Y, Ye S, Fan H, et al. The Impact of Building Uses on Microplastic Pollution and Its Implications for Environmental Education [J]. Scientific Reports, 2025, 15(1): 10391-10391.
27. Moshou H, Drinia H. Strategic Insights for Environmental Education in Greece: SWOT and PEST Analyses in the Context of the Climate Change Crisis [J]. Sustainability, 2025, 17(6): 2633-2633.
28. Wu Yan. Research on School Mental Health Education in an Informatized Learning Environment [J]. Education Modernization, 2018, 5(35): 161-162.
29. Yu Jiayin, Xu Jiamei. Research on the Impact of Smart Learning Environment Construction on Primary and Secondary School Information Technology Classrooms [J]. Computer Knowledge and Technology, 2018, 14(22): 78-80.
30. Liu Ruimei, Meng Xiangzeng. Current Status and Trends in Smart Learning Environment Research [J]. China Adult Education, 2018, (10): 9-13.
31. Cao Zhixi. The Role of Information Technology in Education and Teaching [J]. China New Communications, 2017, 19(21): 132.
32. Sun Pin, Zhou Dongdai, Li Zhen, et al. Research on Student Evaluation Models in Smart Learning Environments [J]. Modern Educational Technology, 2017, 27(10): 121-125.
33. Li Shuang. Research on Junior High School Information Technology Micro-Courses in Ubiquitous Learning Environments [J]. Software Guide (Educational Technology), 2017, 16(02): 12-14.
34. Cui Xiaohui, Zhu Xuan. Design of Smart Learning Environments for Higher Vocational Education in Information Technology Environments [J]. Journal of Changzhou Information Vocational and Technical College, 2016, 15(06): 45-47.
35. Xu Yinan. Research on Reform Strategies of Mechanical Professional Education in Blended Learning Environments [J]. Die & Mould Manufacturing, 2025, 25(03): 88-89+92.
36. Hou Ceng. Research on Higher Education Supply Reform in Ubiquitous Learning Environments [J]. Journal of Liaoning Economic Vocational Technological Institute and Liaoning Economic Management Cadre Institute, 2025, (01): 37-39.
37. Hu Wang, Chen Yao. Research on the Meaning, Functions, and Intelligence of Smart Learning Ecological Environments [J]. China Educational Technology Equipment, 2024, (24): 22-27+34.
38. Gugssa A M. Barriers to Environmental Education in Ethiopia: Do They Differ from a Global Analysis? [J]. International Research in Geographical and Environmental Education, 2025, 34(2): 156-173.
39. Gopinath S, Kumar A. The Effect of an Environmental Education Program Based on Empathy and Reflective Thinking on Preadolescents' Environmental Values and Knowledge [J]. International Research in Geographical and Environmental Education, 2025, 34(2): 100-119.

40. Zhang Ni, Xia Haiyan, Xing Dahui, et al. Research on the Design and Application of Learning Environments Supported by "Three Classrooms": Based on an Educational Ecology Perspective [J]. China Educational Technology, 2024, (11): 87-94.
41. Lin Weining. Research on Strategy Optimization of University Ideological and Political Education in New Media Environment [J]. Teaching in Forest Region, 2025, (03): 14-17.
42. Zhang He. Value Examination and Innovation Paths for Accelerating the Construction of University Education System for the Elderly in the New Era [J]. New West, 2024, (08): 97-101.
43. Zhou Weiqin. Research on Well-being Construction and Mental Health Cultivation in University Education [J]. Journal of Jiamusi Vocational College, 2024, 40(04): 97-99.
44. Tiemann A, Ring I. Quantifying and Mapping Forest-Related Environmental Education and Training in Saxony, Germany [J]. Ecosystem Services, 2025, 73: 101719-101719.
45. Dong Q. Computer-Based Interactive Training in Nature-Based Environmental Education: Impact on Conservation Behaviours, Social Behaviours, and Lower and Higher Order Thinking Skills [J]. Thinking Skills and Creativity, 2025, 57: 101825-101825.
46. Ambreen S, Badwan K, Pahl K. Attending to Children's Voices Within Environmental Education [J]. Childhood, 2025, 32(2): 151-174.
47. Feucht V, Dierkes W P, Kalthoff H A, et al. Environmental Education in Zoos: Analysis of Different Scales to Measure the Impact of Educational Programs [J]. Environmental Education Research, 2025, 31(4): 776-793.
48. Liu Chen. Problems and Development Strategies of Open University Education Management in the Big Data Era [J]. National Common Language Teaching and Research, 2024, (01): 13-15.
49. Zhong Xiaohong. Exploration of the Value and Practical Paths of Family Rules and Family Precepts in University Education [J]. Journal of Lvliang Education College, 2023, 40(04): 1-4.
50. Lai Cuifang. New Practices in Open University Education Management from the Perspective of Smart Education [J]. Journal of Guangxi Radio & TV University, 2023, 34(06): 41-45.
51. Zhang Yong. Optimizing University Education to Realize Students' Self-Value [J]. Shaanxi Education (Higher Education), 2023, (09): 1.
52. Wei Haihan, Zhang Li. University Education Innovation Paths Based on the Concept of Lifelong Education [J]. Science and Education Guide, 2023, (17): 4-6.
53. Bao Han, Liu Qian. Current Status and Solution Strategies of University Education Management in the Information Age [J]. Science and Education Guide, 2023, (05): 53-55.
54. Li Huayu. Application of Student-Centered Educational Concept in the Management of Basic Level Open Universities [J]. Journal of Jilin Radio and TV University, 2023, (01): 111-113.