Wu, J. (2024). What technological factors influence Chinese college student engagemnt in a smart classroom learning environment: Ease of use, perceived usefulness, or multiple sources? In Li, E.Y. *et al.* (Eds.) *Proceedings of The International Conference on Electronic Business, Volume 24* (pp. 576-586). ICEB'24, Zhuhai, China, October 24-28, 2024

What Technological Factors Influence Chinese College Student Engagement in a Smart Classroom Learning Environment: Ease of Use, Perceived Usefulness, or Multiple Sources?

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ABSTRACT

Smart classrooms equipped with advanced technologies and designed to enhance students' learning outcomes are proliferating in many countries, including China. The impact of technological factors on student engagement in smart classroom learning environments (SCLEs) is crucial for shaping the future development of smart classrooms and guiding teachers' training in information technologies. This study delves into the influence of technological factors on student engagement in SCLEs across three dimensions: ease of use, perceived usefulness, and multiple sources. Data were purposefully collected from a cohort of 217 college students enrolled in at least one smart classroom course during the study period. The empirical evidence suggests that these three factors exert varying effects on student engagement. Unexpectedly, only students' perception of multiple sources positively predicts student engagement in SCLEs, while perceived usefulness is negatively correlated with student engagement. Surprisingly, ease of use is not significantly associated with student engagement. This study underscores the limited impact of students' perceptions of technology on their engagement levels, emphasizing instead the importance of pedagogical and social support provided by these technologies in SCLEs. Educators should prioritize such support mechanisms to foster greater student engagement in smart classroom environments.

Keywords: Student engagement, ease of use, perceived usefulness, multiple sources, smart classroom learning environments.

INTRODUCTION

The rapid development of information technology has been reshaping education across various dimensions, encompassing educational resources, teaching methodologies, learning modalities, and learning environments. One such transformative educational setting is the smart classroom, underpinned by an array of sophisticated information technologies that enhance teaching efficacy and diversify learning experiences for college students. Technologies such as wireless internet, digital cameras, recording and casting equipment, multi-touch screens, mobile devices, interactive whiteboards, and educational software empower instructors to deliver instruction effectively, provide instant feedback, and offer attentive support to college students. Simultaneously, these technologies enable college students to conduct investigations, initiate discussions, and engage in peer instruction (Macleod et al., 2018). By fostering a student-centered learning environment, smart classrooms promote increased interaction and participation among college students, catering to their individualized learning needs.

Recognizing the benefits of smart classrooms, China has allocated significant government funding to facilitate their widespread implementation across all levels of education (Huang et al., 2012; MOE, 2017). The study of learning environments has gained international prominence over the past three decades, emerging as a focal point in educational research. It has been established that the learning environment significantly influences college students' academic achievements (Reynolds, 1992; Fraser, 2002; Brophy, 2006). Consequently, understanding college students' perceptions of their learning environment, particularly regarding technology integration centered around student needs, has become a matter of paramount importance. Fraser (1998) contends that comprehending the learning environment through participants' perceptions is crucial.

The increasing integration of technology into the classroom has had a significant impact on the way students learn and study during in-class time. Digital devices like laptops, tablets, and smartphones have become ubiquitous, allowing students to access a wealth of information and educational resources at their fingertips. This has enabled more interactive and engaging lessons, with teachers leveraging multimedia content and collaborative online tools to enhance the learning experience. Junco et al., (2011) suggest that students who took classes using social media were found to have statistically significant higher degree of engagement. Sun and Rueda (2012) found that online activities may be a means of increasing students' emotional engagement.

However, the presence of technology has also introduced new challenges, as students can become distracted by non-academic uses of their devices or struggle to effectively manage digital distractions. In-class distractions and disengagement lead to poor academic performance (Bergdahl et al., 2020). Some educators also question the learning outcomes in technology-mediated learning environment, because technology-mediated learning requires more self-discipline on the part of students. Although it does not require "same-time, same-place" learning, it might not effectively facilitate "deep learning," particularly when students lack the intrinsic motivation to acquire knowledge (skills) from the technology-enabled learning platform(Martens et al., 2007).

College student engagement constitutes a vital area of inquiry within educational research, particularly within the field of educational psychology (Gunuc & Kuzu, 2015). Numerous studies have demonstrated a positive correlation between college student engagement, learning outcomes, and academic achievement (Carini et al., 2006; Coates, 2005; Park, 2005). However, scant attention has been paid to how college students' perceptions of smart learning environments influence their engagement. College students' perception for the technologies employed in smart classrooms may significantly impact their engagement within this learning milieu.

With the widespread of smart classroom learning environments(SCLEs) in China, many researchers explore the relationships between technologies and academic learning. Technology has reformed the teaching-learning in class, but the specific connection with students' perceptions of technology and their engagement needs further exploration. Therefore, the present study delves into the impact of college students' perceptions of the technologies in SCLEs on their engagement levels.

The ensuing literature review expounds upon college student engagement within technology-enhanced classrooms, their perceptions of technologies utilized therein, and the rationale for examining the interplay between college student engagement and their perceptions for technologies within smart classrooms. The findings should be able to make contribution to our limited understanding about the impact of student perception of technologies on their engagement.

THEORETICAL BACKGROUND

This study is guided by the technology acceptance model (TAM) and constructivism. The TAM explains how the perceived usefulness and ease of use of technology can influence user acceptance and satisfaction (Davis, 1989). Students' satisfaction toward technology in education settings can predict higher levels of motivation, participation, and better learning outcomes.

The smart classroom learning environment is a typical constructivist learning environment that emphasizes personalized relevance, shared control over learning, open expression of learning-related concerns, and interactive collaboration to improve learning(Taylor et al., 1997). The integration of diverse technologies, such as interactive whiteboards, wireless connectivity, computing devices, educational software, and collaborative tools, creates an immersive learning space where students can customize their learning materials, diversify their interaction and communication, and seamlessly blend face-to-face and digital instruction. This technology-enriched, student-centered approach aligns with the core principles of constructivism, empowering learners to actively construct their knowledge and meaning through exploration, experimentation, and social exchange within the smart classroom setting.

By integrating TAM and construtivism, this study aims to provide a more comprehensive understanding of the complex interplay between students' perception of technologies and student engagement in smart learning environments.

College Student Engagement in SCLEs

College student engagement has primarily been examined in terms of cognitive, emotional, and behavioral aspects (Fredricks et al., 2004). Student engagement in SCLEs has garnered considerable attention from scholars, yielding varying research findings. While many studies affirm that technology can enhance student engagement, there are disparities in their conclusions. For instance, web-based learning technologies have been shown to positively impact student engagement and learning outcomes (Chen et al., 2010), and interaction-oriented software on digital devices has been found to enhance engagement in SCLEs (Saini & Goel, 2019). Moreover, Schindler et al.'s review (2017) demonstrates that five popular technologies—web-conferencing, blogs, wikis, social networking sites, and digital games—positively influence multiple indicators of college student engagement, potentially yielding significant returns on investment in terms of learning outcomes. Sung et al.'s study (2016) reveals that the overall impact of using mobile devices in education surpasses that of desktop computers or not using mobile devices as an intervention.

However, the use of technologies such as mobile devices, multimedia materials, and learning software has been associated with increased student engagement, albeit with modest effects (Wang et al., 2022). Some studies suggest that the influence of technology use on student engagement is limited. For instance, research indicates that technology support in SCLEs may primarily promote shallow cognitive engagement (Lu et al., 2022). Moreover, Thomas et al.'s study (2019) indicates that in smart learning environments, the perceived ease of use of technology does not significantly affect perceived learning. The discrepancies in these findings may stem from the scope of technology examined in the studies—ranging from broad coverage of various technologies to a narrow focus on specific functions, little attention paid to students' perceptions of the technology use in SCLEs. Thus, the discrepancy in the student engagement in the technology-enhanced environment prioritizes the need to research the influence of different dimensions of technology perception over student engagement in SCLEs.

College Student Perception of SCLEs

Classrooms should be designed to create optimal learning environments that foster college student learning (Roskos & Neuman, 2011). College students' perceptions of the classroom can be categorized into three main areas: perception of the social environment, encompassing factors like belongingness and connection with classmates; perception of the psychological environment, including motivation, self-efficacy, and achievement; and perception of the physical environment, such as classroom size, lighting, and technology. Both social and psychological environment is closely associated with the physical learning environment because it is the place where learning happens. Research indicates that the physical environment has significant impact on students' health, enjoyment and learning (Zheng et al., 2013). Therefore, it is of great necessity to research the physical environment in educational settings. However, existing studies predominantly focus on traditional classrooms, and scant attention has been paid to the smart classroom.

Smart classrooms, characterized by rich information technologies that support student-centered learning environments, offer technological resources for college students to explore topics, engage in discussions, and express opinions. Perception of media support, perception of teacher support, and perception of social support are the three factors influencing environmental perception in SCLEs (Lu et al., 2022). These factors are centered around and transformed by the information technologies present in SCLEs. It is technologies such as wireless internet, interactive whiteboards, multi-screen displays, education management software, and mobile devices that reshape instructional methods and learning approaches, thereby transforming interaction and socialization within the classroom. Therefore, it is essential to study the influence of technological factors on student engagement in SCLEs.

Perceptions of technology in SCLEs

Perceived usefulness(PU) and perceived ease of use(PEOU) of a technology are naturally related to the objective characteristics of that technology – what the Technology Acceptance Model (TAM) refers to as the "system features" that the user observes. PU and PEOU form an end-user's beliefs on a technology and therefore predict his or her attitude toward the technology, which in turn predicts its acceptance(Ma & Liu, 2004). SCLEs feature advanced technologies, so it is necessary to evaluate students' perception of the technological factors from those two aspects.

Besides those two scales concerning students' perception of technologies, the multiple sources, various relevant and multiple information sources built upon and provided by technologies are also essential in SCLEs. They are closely related to pedagogical and social support provided by technologies.

Therefore, this study examines the technological factors across those three dimensions: perceived ease of use, perceived usefulness, and perceived multiple sources.

RESEARCH QUESTIONS

Smart Classroom Learning Environments (SCLEs), emblematic of the profound integration of education and information technology, are designed to enrich the learning experience, promote digital literacy, facilitate personalized learning, foster collaboration and communication, expand access to educational resources, and enhance multimedia and multimodal learning. College student engagement is crucial for learning, performance, retention, persistence, experience, and achievement (Appleton et al., 2006; Bryson & Hand, 2007), serving as a reflection of students' learning outcomes within SCLEs.

Today's college students, often referred to as "digital natives", have grown up in a digital era characterized by the omnipresence of technology, particularly digital devices and the internet. They are accustomed to learning through various digital platforms and possess a heightened awareness of information technology, enabling them to discern the nuances of technologies in SCLEs. Previous studies have primarily focused on the relationship between college student engagement and the utilization of technologies, such as software and digital devices, yet the impact of technology use on college student engagement remains a subject of debate.

This study aims to investigate the relationship between college student engagement (behavioral engagement, cognitive engagement, and emotional engagement) and their perception of technology use (ease of use, perceived usefulness, and multiple sources) with the goal of enhancing college student engagement in SCLEs. The research questions and hypotheses are stated below:

Research Question:

How does college students' perception of technologies in SCLEs affect their engagement?

Hypotheses:

H1: College students' perceived ease of use of technologies in SCLEs can positively predict their engagement, such that ease of use is positively associated with the behavioral (H1a), cognitive (H1b) and emotional (H1c) engagement.
H2: The college students' perceived usefulness of technologies in SCLEs can positively predict their engagement, such that perceived usefulness is positively associated with the behavioral (H2a), cognitive (H2b) and emotional (H2c) engagement.
H3: The college students' perceived multiple sources provided by technologies in SCLEs can positively predict their engagement, such that perceived multiple sources are positively associated with the behavioral (H3a), cognitive (H3b) and emotional (H3c) engagement.

LITERATURE REVIEW

Student engagement

Student engagement is a critical factor in educational outcomes, influencing not only students' academic success but also their overall learning experience and development. It is commonly defined as the degree to which students participate in and invest in their learning activities. Fredricks, Blumenfeld, and Paris (2004) categorize engagement into three primary components: behavioral engagement, cognitive engagement and emotional engagement. Their definitions of student engagement are as follows:

Behavioral Engagement involves students' active participation in academic and extracurricular activities. It encompasses behaviors such as attending classes, participating in discussions, completing assignments, and following school rules. Cognitive engagement refers to the mental effort students invest in learning. It includes the use of learning strategies, persistence in overcoming challenges, and deep processing of information. Emotional engagement pertains to students' affective responses to their educational experiences. It involves their feelings of interest, enjoyment, and enthusiasm toward learning.

Student engagement is influenced by various factors, including instructional strategies, classroom environment, and so on. Effective instructional strategies play a significant role in promoting student engagement. Research indicates that active learning techniques, such as collaborative learning, problem-based learning, and the use of technology, enhance engagement and learning outcomes by making learning more interactive and relevant (Freeman et al., 2014). Teachers' use of engaging and varied instructional methods can stimulate students' interest and participation.

The classroom environment, including the physical setting, social climate, and teacher-student relationships, affects student engagement. A positive and supportive classroom environment fosters engagement by creating a space where students feel safe, valued, and motivated (Pianta et al., 2014). Classroom management practices and the emotional support provided by teachers are also crucial for maintaining high levels of engagement. Therefore, the technology-enhanced smart classroom designed to support active in-class interaction and diversify students' learning experiences seems to promote students' engagement.

Perceived ease of use and student engagement

Technology Acceptance Model (TAM) posits that perceived ease of use and perceived usefulness are critical determinants of technology acceptance and usage (Davis, 1989). Perceived ease of use refers to the degree to which a person believes that using a technology will be free of effort. According to TAM, technologies perceived as easy to use are more likely to be adopted and engaged with by users. This model provides a useful framework for understanding how perceived ease of use influences different facets of engagement in SCLEs.

Previous studies indicate that when students find technologies easy to use, they are more likely to engage in learning. In a study by Adwan et al. (2013), perceived ease of use had a signifcant effect on attitude. This result is in line with the finding that perceived ease of use and perceived usefulness have a positive impact on attitude as well as behavioral intentions(Fathema et al., 2018). Additionally, ease-to-use system will enhance productivity and performance in turn positively motivate the students in adopting online learning (Chahal & Rani, 2022). Therefore, it seems that the perceived ease of use seems to have impact on students' learning experience in SCLEs, including the engagement. Hence, the following hypothesis is proposed
H1: College students' perceived ease of use of technologies in SCLEs can positively predict their engagement, such that ease of use is positively associated with the behavioral (H1a), cognitive (H1b) and emotional (H1c) engagement.

Perceived usefulness and student engagement

Perceived usefulness, about the degree to which the technology is perceived to enhance job performance, another core construct of the Technology Acceptance Model (TAM), also plays a vital role in influencing technology adoption and engagement (Davis, 1989). TAM posits that perceived usefulness, along with perceived ease of use, determines users' attitudes towards technology and their intention to use it (Davis, 1989). Technologies perceived as useful are more likely to be embraced by users, leading to higher levels of engagement and participation.

Research has demonstrated that perceived usefulness is positively associated with learning experience. Al-Azwaei and Lundqvist (2015) pointed that perceived usefulness is the best predictor of perceived satisfaction. Additionally, perceived usefulness has a signifcant infuence on attitude and behavioral intentions (Kanwal & Rehman, 2017). Students' satisfaction, positive attitude and behavioral intentions are closely related with student engagement. Based on these studies, the hypothesis is proposed:
H2: The college students' perceived usefulness of technologies in SCLEs can positively predict their engagement, such that perceived usefulness is positively associated with the behavioral (H2a), cognitive (H2b) and emotional (H2c) engagement.

Multiple sources and student engagement

In the context of SCLEs, technologies that offer multiple sources of information, diverse presentations and instructions can provide a richer learning experience. This variety can cater to different learning styles and preferences, potentially increasing engagement.

The multiple sources in SCLEs greatly rely on information communication technologies(ICT) which prove to have positive influence over learning outcomes. For example, the learning platforms (LPs) (virtual learning environments, management information systems, communication technologies, and information- and resource-sharing technologies) in schools allowed students to access a wider variety of quality learning resources, engage in independent and personalized learning, and conduct self- and peer-review(Jewitt & Hadjithoma, 2011). Additionally, the use of ICTs helps students access digital information and course content effectively and efficiently, supports student-centered and self-directed learning, as well as the development of a creative learning environment where more opportunities for critical thinking skills are offered, and promotes collaborative learning in a distance-learning environment(Fu, 2013). The use of ICT resulted in further positive gains for students, namely increased attention, engagement, motivation, communication and process skills, teamwork, and gains related to their behaviour towards learning (Timotheou et al., 2022). Therefore, the multiple sources in SCLEs seem to have positive impact on learning.
Based on previous research, the following hypothesis is proposed:
H3: The college students' perceived multiple sources provided by technologies in SCLEs can positively predict their engagement, such that perceived multiple sources are positively associated with the behavioral (H3a), cognitive (H3b) and emotional (H3c) engagement.

We build a study model to examine the interrelationships among variables potentially influencing students' engagement in light of the previously described theoretical variables and proposed linkages. The proposed model, explicated in Figure 1, forms the basis of the exploration.

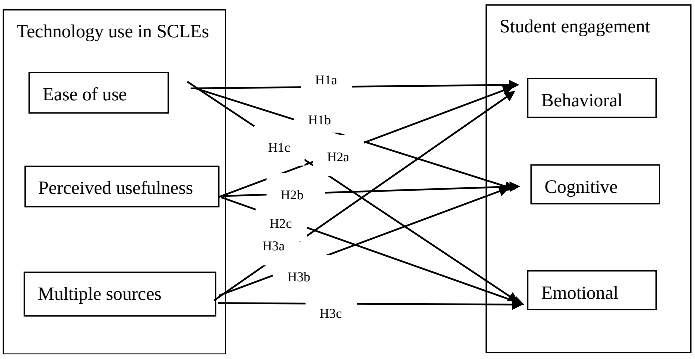

Fig.1 Research model and hypothesis

DATA COLLECTION

Measures

Technology Use: College students' perceptions of technology use in SCLEs were evaluated using the Chinese version of the Preference Instrument of Smart Classroom Learning Environments (Macleod et al., 2018). Three dimensions were assessed: Ease of Use (EU, 5 items), Perceived Usefulness (PU, 5 items), and Multiple Sources (MS, 5 items). These dimensions capture the ease of use, perceived usefulness, and multiple sources presented by technologies and softwares in SCLEs. Respondents rated 15 items on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability of the questionnaire was assessed through a pilot study with 50 learners from the same population, yielding a Cronbach's Alpha coefficient of 0.97 ($\alpha = 0.97$).

Student Engagement: College student engagement was assessed using the Scale of Student Engagement (Reeve & Tseng, 2011). This scale measures three dimensions of engagement: Behavioral Engagement (BE, 3 items), Cognitive Engagement (CE, 3 items), and Emotional Engagement (EE, 3 items). Participants rated all items on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability of the questionnaire was verified through a pilot study with 50 learners from the same population, resulting in a Cronbach's Alpha coefficient of 0.98 ($\alpha = 0.98$).

Participants

The participants in this study were students enrolled at a 4-year university located in central China. This university has made significant investments in technology-enhanced learning environments, facilitating access to smart classrooms across various disciplines. Participants were selected based on their current enrollment in courses conducted within smart classrooms, ensuring ongoing experience with this learning environment. Data collection took place efficiently at the end of April 2024, resulting in 217 valid questionnaires from university students in Hubei Province, China.

All participants were briefed on the study's objectives and voluntarily chose to participate. The survey was conducted using the web-based platform "Survey Star", a well-known tool in China. Prior to data collection, necessary permissions were obtained from the university.

Regarding participant demographics, 65 (30%) were male, and 152 (70%) were female. In terms of academic level, 74 (34.1%) were first-year students, 66 (30.4%) were second-year students, and 77 (35.5%) were third-year students. Seniors were not included in the study as they were focused on thesis work and did not enroll in courses during their fourth year.
The collected data were analyzed using SPSS (version 23) and AMOS (version 26).

DATA ANALYSIS

Data analysis proceeded in two steps. Initially, Confirmatory Factor Analysis (CFA) was conducted to determine the variables to be included in the final analysis. Subsequently, the proposed model was examined using data based on the selected variables.

In the first step, a series of single-level CFAs were performed for technology use and student engagement to assess their underlying structures. However, the results of discriminant validity did not support the three-factor structure of technology use. Notably, the regression path coefficient of PU3 (Improves my ability to communicate with others) was high, while the regression path coefficients of EU2 (Have user-friendly learning devices and software) and MS4 (Share content from the teacher and other students through digital devices) were low. Consequently, these three variables were excluded from the model.

In the second step, the proposed model was re-examined. The results indicated that all measurement models were largely acceptable, as presented in Table 1, which displays fit indices meeting acceptable criteria (Hu & Bentler, 1999). Although the Root Mean Square Error of Approximation (RMSEA) for the student engagement model was slightly higher than the acceptable threshold, it remained on the borderline. Overall, the model fitness values signify statistical significance and warrant further analysis.

Table 1: Fit indices

	Acceptable values	**Model values**		
Fit index		Technology use	Student engagement	Technology use-student engagement
CMIN/DF	≤5	2.973	3.507	2.705
RMSEA	≤0.08	0.082	0.089	0.079
TLI	>0.8	0.942	0.962	0.928
CFI	>0.8	0.955	0.981	0.941

Convergent Validity and Internal Reliability

Convergent validity and internal reliability were assessed using the Average Variance Extracted (AVE) and Composite Reliability (CR), respectively. Generally, an AVE greater than 0.5 and a CR greater than 0.7 indicate high convergent validity and internal reliability.
As presented in Table 2, the results demonstrated acceptable convergent validity and internal reliability for all scales. All the Cronbach's Alpha(α) higher than 0.8, imply all the scales have a relatively high internal consistency.

Table 2: Convergent validity and internal reliability

	EU	**PU**	**MS**	**BE**	**CE**	**EE**
AVE	0.654	0.757	0.677	0.822	0.861	0.81
CR	0.811	0.926	0.893	0.933	0.949	0.927
A	0.861	0.924	0.892	0.931	0.948	0.927

Perception of technological factors

Descriptive statistics and correlations of variables in the Technology Use Scale and Student Engagement Scale are reported in Tables 3 and 4, respectively.
In Table 3, students' perceptions indicate that the lowest level of perception regarding technology integration in a smart learning environment was related to ease of use (M = 4.006, SD = 0.820). Students reported experiencing higher levels of multiple sources (M = 4.167, SD = 0.689) compared to perceived usefulness (M = 4.138, SD = 0.744). Students exhibited the highest agreement ratings for perceptions of multiple sources, followed by perceived usefulness. They tended to moderately agree with perceptions of ease of use in the smart learning environment. These three variables were significantly associated with each other. Multiple sources showed a strong association with perceived usefulness (r = 0.879), followed by the association between ease of use and perceived usefulness (r = 0.766), and the association between ease of use and multiple sources (r = 0.747).

Table 3: Means, standard deviations, and correlations of variables in technology use scale

Variables	**M**	**SD**	**EU**	**PU**	**MS**

EU	4.006	0.820	1		
PU	4.138	0.744	.766**	1	
MS	4.167	0.689	.747**	.879**	1

Student Engagement Results

The results of student engagement, as shown in Table 4, reveal that the lowest level of student engagement in a smart learning environment pertained to behavioral engagement (M = 3.974, SD = 0.763). Students reported being more emotionally engaged (M = 3.992, SD = 0.746) than cognitively engaged (M = 3.982, SD = 0.783) in the smart learning environment. Students exhibited the highest agreement ratings for emotional engagement, followed by behavioral engagement. They tended to moderately agree with cognitive engagement in the SCLEs. These three variables were significantly associated with each other. Cognitive engagement exhibited a strong association with emotional engagement (r = 0.882), followed by the association between behavioral engagement (r = 0.833) and the association between behavioral engagement and cognitive engagement (r = 0.830).

Table 4: Means, standard deviations, and correlations of variables in student engagement scale

Variables	**M**	**SD**	**BE**	**CE**	**EE**
BE	3.974	0.763	1		
CE	3.982	0.783	.830**	1	
EE	3.992	0.746	.833**	.882**	1

SEM Path Analysis Results

Table 5 presents the results of the Structural Equation Model (SEM) path analysis, examining the factors affecting student engagement in the smart learning environment.

Ease of use was not found to be significantly associated with student engagement. Specifically, ease of use did not demonstrate significant associations with behavioral engagement ($\beta = -0.308$, $p = 0.52$), cognitive engagement ($\beta = -0.31$, $p = 0.619$), and emotional engagement ($\beta = -0.28$, $p = 0.586$). Consequently, Hypothesis 1 (H1) was not supported.

Perceived usefulness, on the other hand, exhibited significant associations with student engagement, but negatively. Perceived usefulness was significantly associated with behavioral engagement ($\beta = -5.619$, $p = 0.05$), cognitive engagement ($\beta = -7.606$, $p = 0.042$), and emotional engagement ($\beta = -6.138$, $p = 0.046$). Perceived usefulness is significantly associated with student engagement in the SCLEs and can negatively predict it. Thus, Hypothesis 2 (H2) was not supported.

Similarly, multiple sources demonstrated significant associations with student engagement. Multiple sources were significantly associated with behavioral engagement ($\beta = 6.687$, $p = 0.025$), cognitive engagement ($\beta = 8.663$, $p = 0.026$), and emotional engagement ($\beta = 7.187$, $p = 0.025$). Hence, Hypothesis 3 (H3) was supported, indicating that multiple sources are significantly associated with student engagement in the SCLEs and can positively predict it.

Table 5: SEM path analysis of factors affecting student engagement

Hypothesis		**Path**		**Estimate**	**S.E.**	**C.R.**	**P**
H1a	BE	<---	EU	-0.308	0.456	-0.643	0.52
H1b	CE	<---	EU	-0.31	0.605	-0.497	0.619
H1c	EE	<---	EU	-0.28	0.475	-0.545	0.586
H2a	BE	<---	PU	-5.619	2.992	-1.958	0.05
H2b	CE	<---	PU	-7.606	3.987	-2.031	0.042
H2c	EE	<---	PU	-6.138	3.119	-1.992	0.046
H3a	BE	<---	MS	6.687	4.099	2.244	0.025
H3b	CE	<---	MS	8.663	5.455	2.23	0.026
H3c	EE	<---	MS	7.187	4.27	2.248	0.025

DISCUSSION

The current study investigated the relationship between students' perception of technology integration comprising ease of use, perceived usefulness, and multiple sources in the SCLEs and student engagement including behavioral engagement, cognitive engagement, and emotional engagement within SCLEs. This research provides valuable insights into student engagement within SCLEs by examining the impact of students' perceptions of technological factors on engagement. The standardized estimation model is depicted in Fig. 2.

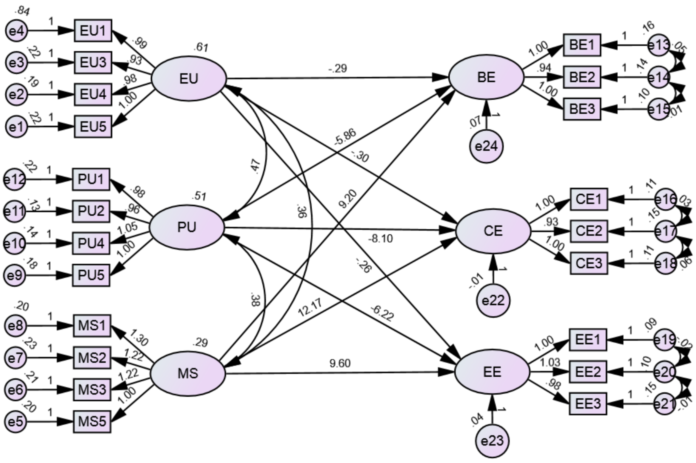

Fig.2 SEM analysis model

The study yielded unexpected findings regarding the relationship between students' perception of technology integration and student engagement in SCLEs. Notably, ease of use did not influence student engagement in SCLEs and showed no significant association with any dimension of student engagement. Perceived usefulness was found to be negatively associated with student engagement, while multiple sources provided by technologies in SCLEs positively predicted student engagement.

Contrary to expectations, the study found no significant association between ease of use and student engagement, and perceived usefulness was negatively related to student engagement in SCLEs. Despite encompassing various aspects such as studying experience, information presentation, communication, and interaction, the perceived usefulness of technologies in SCLEs did not promote student engagement. These results are inconsistent with most previous studies that propose that technologies can enhance students' learning outcomes. However, a few prior studies have also mentioned that the impact of technologies on study may be limited. Van De Bogart & Wichadee(2016) indicate that the perceived effectiveness of technology does not correlate with learning outcomes. Moreover, Lu et al.(2022) propose that technology support only promotes superficial engagement. Therefore, the impact of technology-enhanced learning environments on student engagement still remains controversial. The future research can expand the sample size and take mixed methods to better explore the linkage.

The study revealed that multiple sources significantly contribute to student engagement in SCLEs. This scale, focusing on the pedagogical and social affordances provided by technologies, emphasizes diverse perspectives in discussions, various presentations, and diversified learning information. This finding aligns with previous research(Cho et al., 2015) indicating that pedagogical and social affordances primarily influence learning effectiveness, with technology serving as a supporting tool. It is not the use of technology in itself but how technology is used that matters. Therefore, effective student engagement in SCLEs may depend more on pedagogical and social affordances rather than technology support.

CONCLUSION

The present research highlights that engaging students effectively in SCLEs depends on pedagogical and social affordances rather than technology support alone. It underscores the importance of how technologies are utilized to assist classroom instruction rather than the technologies themselves.

Information technology is revolutionizing education, prompting numerous countries to invest in technology-enhanced learning environments. Understanding how these environments can promote student engagement is crucial. This study offers empirical evidence regarding the technological factors essential in the technology-enhanced learning environment. Specifically, ease of use was found to be unrelated to student engagement, perceived usefulness was negatively related to student engagement, and only multiple sources built upon technologies positively influenced student engagement.

Theoretical Implications

This study expands the understanding of technological factors in SCLEs. The findings challenge the conventional wisdom that students' perceptions of ease of use and usefulness are the primary drivers of engagement in technology-enhanced learning environments. Instead, the results highlight the critical role of the availability of multiple information sources enabled by SCLEs. Furthermore, this study emphasizes the limitations of technology acceptance models. The lack of a significant relationship between perceived ease of use and student engagement and the negative association between perceived usefulness and student engagement suggest that traditional technology acceptance models like TAM may have limited applicability in the SCLE context. Other factors beyond just technology perceptions may be more salient in predicting student engagement. Additionally, this research shifts the focus to pedagogical and social support. The results underscore the importance of the pedagogical and social affordances of SCLEs, rather than just their utilitarian features, in fostering student engagement. This implies the need for a more holistic perspective on technology integration in learning environments. Last, this research identifies the nuanced relationship between technology and engagement: The finding that the perceived usefulness is negatively associated with engagement suggests a more complex interplay between technological factors and student behaviors in SCLEs, warranting further investigation.

Practical Implications

The findings of this study offer several important practical implications for educators and instructional designers. First, the findings prioritize multiple sources over ease of use and usefulness. When designing and implementing SCLEs, educators should focus more on providing students with access to a diverse range of sources, rather than solely emphasizing the ease of use or perceived usefulness of the technologies. Second, this study indicates the importance of pedagogical and social support mechanisms. Educators should devote greater attention to leveraging SCLE technologies to strengthen the pedagogical and social support provided to students, as these factors appear to be more influential in driving student engagement than the mere technological features. Third, the results inspire educators to rethink the assessment of technology integration. Institutions should consider adopting more holistic approaches to evaluating the effectiveness of technology integration in learning environments, moving beyond simplistic metrics of ease of use and perceived usefulness to include measures of pedagogical and social impact on student engagement and learning outcomes. Last, this research encourages to foster a culture of technology-enabled, student-centered pedagogy. Institutions should work to cultivate a campus-wide culture that values the strategic use of SCLE technologies to support student-centered, active learning approaches, rather than viewing technology merely as a tool for enhancing instructional efficiency.

Limitations and Future Directions

Despite its contributions, this study has limitations. Additional influencing factors, such as teachers' technology knowledge and course features, may impact technology's influence on student engagement. Furthermore, relying solely on questionnaire data limits the depth of analysis, warranting the inclusion of multimodal data in future studies. Lastly, this study focused on a single university, suggesting the need for future research to involve students from various universities for a comprehensive evaluation of technology's influence on student engagement.

ACKNOWLEDGEMENT

This research is sponsored by the Team for High-quality Development of Cross-border E-commerce in Wuhan Business University, the Education Research Program for Higher Education Institutions in Wuhan City, Hubei Province (Grant No. 202339), and the Instructional Program of Philosophy and Social Sciences for Higher Education Institutions in Hubei Province (Grant No. 21G112).

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