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Impact of Smart Classroom Preferences on Critical Thinking Skills of Chinese Pre-Service Teachers: The Role of Moderating Cognitive Learning Strategies

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Abstract: This study aims to determine the influence of pre-service teachers' preferences for smart learning environments on their critical thinking skills and moderating role of cognitive learning strategies. Critical thinking skills are essential for teachers as they enable them to analyse information, solve complex problems, and make informed decisions, ultimately enhancing their effectiveness in educating and guiding students. This quantitative study using multivariate analysis collected responses from preservice teachers from four colleges and universities in China. The sample size was 686 preservice teachers (M = 21 years, SD = 1.19 years; 65.6% female). SPSS v.26.0 was used to analyse the data. The results showed that there is a positive correlation between students' preferences for smart classroom environment components and critical thinking skills. Moreover, the findings revealed that reflective thinking, inquiry-based learning, ease of use, and perceived usefulness influence the preservice teachers' critical thinking skills. The results also showed that cognitive learning strategies significantly moderated their hypothesised associations. The results of the study can assist educators and curriculum designers in creating more challenging smart learning opportunities and evaluation systems.

Keywords: critical thinking skills, learning environment, smart classroom, students' preferences

1. Introduction

The emergence of new technology has significantly altered the state of the world economy. The social lives of people increased knowledge and technological advancement while introducing new standards for human abilities (Singh et al., 2022). The most current distributed ledger technology has been used to improve the traditional educational system in developing countries. Smart classrooms are therefore developing as a substitute paradigm that combines critical thinking skills (CTS) with cutting-edge technology to enhance learners' performance (Li et al., 2019). With these developments, students can skim through huge amounts of information provided by various sources, which makes them incapable of integrating the information they have received. Hence, in recent years knowledge management and higher-order thinking skills such as CTS have become important topics in higher education (HE)(Zhou et al., 2023).

CTS is necessary to help students advance their skills and serves as a source of information and new ideas. Due to these reasons, universities in several countries have begun to equip students with 21st century skills including problem-solving, collaboration, creativity as well as CTS which are necessary to face the rapid development and challenges of this new era (González-Pérez & Ramírez-Montoya, 2022). This suggests that there is a need for students who can integrate knowledge from many fields, absorb information, assess issues, and solve them efficiently. Thus, 86% of countries included 21st century skills in some aspect of their curriculum (Zhou et al., 2023).

Preservice teachers are the teaching force's backup and must have strong thinking skill competencies to produce students with these skills (Brandt et al., 2021). This implies the need of improving 21st century skills among preservice teachers to help them stimulate the learning process of their future students. Thus, following the successful experience of schools, universities have created smart classrooms to prepare their students' intellectual skills (Lu et al., 2021).

A physical classroom is referred to as a "smart classroom" if it incorporates cutting-edge educational technology to give students possibilities for formal educational learning experiences that go beyond what regular classrooms can deliver (MacLeod et al., 2018; Zaremohzzabieh et al., 2022). A smart classroom is a physical space equipped with advanced technology and digital tools to enhance teaching and learning, while a smart learning environment encompasses a broader concept that includes not only technology-enhanced classrooms but also online platforms, virtual resources, and personalised learning experiences, collectively fostering a digitally enriched and adaptive educational ecosystem (Kaur et al., 2022). A technologically advanced classroom setting can boost students' enthusiasm, encourage active learning, and enhance CTS for use when they enter the job. The specific technologies employed in the smart classroom vary but typically employ educational management software to provide a blended learning experience (Kaur et al., 2022).

Academic performance is frequently the focus of educational research, however, these metrics cannot provide a comprehensive description of learning events (Nagy & Molontay, 2021). Students' perceptions of the elements of the learning environment might offer insightful comparisons when describing scholarly communication and events. According to research, the most pertinent cognitive, metacognitive, social, physical, material, and technical elements of the learning environment should be measured (Yu et al., 2022). Parallel constructivist technologically enabled settings have all had their learning environment characteristics assessed (Maor, 1999). These results provided crucial information that may be used to create a more suitable learning environment, such as smart classrooms, which enable face-to-face contact and collaboration instead of only using online learning settings. Through a smart classroom environment, students can understand the subject being taught and develop their thinking skills (Palanisamy et al., 2020).

Only a small number of colleges have smart classrooms, however, and implementation of these technologies is quite gradual. Thus, assessing the outcomes of such classrooms on students' abilities, such as CTS, needs to be clarified. Prior research has suggested that a smart classroom environment may be affected by students' preferences for learning environments, or their perceptions of a particular learning environment (e.g., Lu et al., 2021). Therefore, the current study examines the relationship between preferences for socialisation and other crucial learning environment features among pre-service teachers, concentrating on the face-to-face component of the smart classroom among those pre-service teachers with at least one full semester of experiential learning in this environment.

Countries like China have focused more on cultivating students' CTS in HE (Ministry of Education, 2020). Teaching CTS effectively has been a major challenge to educators in China. Furthermore, the Ministry of Education (2020) issued "The Implementation of Outstanding Teacher Training Plan 2.0 ", which clearly stated, "After five years of efforts, we will cultivate a group of high-quality preservice teachers" with CTS. Since 2016 smart classrooms have become increasingly popularized for developing CTS in China (Xing & Lu, 2022). Furthermore, enhancing the CTS of students in Chinese educational institutions is in its infancy stages. Many Chinese universities have been reconstructing the smart learning environment and building "smart learning classrooms" (Wang, 2021). However, recently, some studies have shown that the CTS level of Chinese students, including preservice teachers, is still in the middle, which indicates that attempts to teach CTS among preservice teachers have not been fully successful in China because most institutions neglect the student's preferences in such classes (e.g., Ma & Luo, 2021).

2. Literature Review

According to Kordt (2018), the learning environment affords learners' thinking to act effectively. However, the learner's intentions, perceptions, and preferences influence their learning outcomes and thinking abilities. It means that the learning environment provides learners with opportunities and possibilities for certain learning activities, but how these opportunities and possibilities are perceived and utilised by the learners is closely related to the learner's perceptions (Park & Song, 2015).

Gibson's (1986) Affordance Theory of ecological psychology introduced the idea of actor-environment mutuality in which affordance results from the interaction between the environment and the organism. Organisms are defined as actors, which perceive and behave in the environment, while affordances mean the possibilities and opportunities the environments afford actors to achieve some specific goals. However, Gibson (1986) argued that the affordances need to be perceived by actors to achieve the properties and effects. Furthermore, it is emphasised that actors' perception and actualization of affordances is a goal-oriented process that could further determine the effects of the affordances (Kordt, 2018). In the context of explaining the influence of the educational environment on student critical thinking, this theory suggests the following points:

1. **Perception of Environmental Affordances**: According to the theory, individuals perceive the environment in terms of its affordances - the potential actions and interactions it allows. In an educational setting, the physical layout, tools, resources, and learning materials are all affordances that students can perceive (Gibson, 1986).
2. **Engagement and Interaction**: The educational environment's design and layout can encourage certain types of engagement and interaction.
3. **Situational Constraints and Opportunities**: Affordances also include situational constraints, which limit certain actions while enabling others. An environment with limited access to information resources or where teacher-centred instruction prevails might constrain students' critical thinking development.
4. **Social Interactions:** This theory acknowledges the role of social interactions in shaping perceptions of the environment. Peer interactions, teacher-student discussions, and collaborative projects within the educational environment create opportunities for sharing ideas, receiving feedback, and refining one's critical thinking through collective sense-making.
5. **Feedback Loop:** Students' actions and interactions within the educational environment lead to feedback that further informs their perception of affordances. If students' attempts at critical thinking are met with encouragement and support, they are likely to perceive the environment as conducive to such activities, thereby reinforcing the development of their critical thinking skills.
6. **Adaptation and Learning:** Affordances are not static; they evolve as students adapt to their environment. If students are consistently encouraged to engage in critical thinking activities, they are more likely to perceive the environment as one that supports such behaviours. This can create a positive feedback loop, enhancing their critical thinking skills over time.

2.1 Students' Preferences for a Smart Classroom Learning Environment

The dynamic atmosphere that the smart classroom generates boosts students' interest in their lessons (Phoong et al., 2019). According to Malik and Shanwal (2017), a smart classroom environment allows students to choose their own pace of learning, is interactive, promotes teamwork, and allows them to use the online portal to conduct research. This multidimensional space involves some aspects of constructivist learning, such as student-negotiated learning (SN), inquiry-based learning (IBL), reflective thinking (RT), ease of use (EOU), perceived usefulness (PU), multiple sources (MS), connectedness (CN), and functional design (FD). These affordances could provide opportunities for students to engage in some high-level learning activities (Yang et al., 2018). However, students need to adopt corresponding cognitive learning strategies (CLS) to actualize the affordances. This process would be influenced and driven by goal orientations, which further determines the achievement of the affordances' effects on developing the CTS. Thus, students' preferences for a smart classroom learning environment (PSCLE) are important for understanding the functionality of smart classrooms from the user perspective (Zhang et al., 2020). Previous studies have investigated students' PSCLE to improve the effectiveness of the smart classroom (e.g., MacLeod et al., 2018).

Negotiation is a procedure in which two parties with disagreements strive to achieve an agreement by examining possibilities and exchanging ideas - achieving an agreement. In smart learning settings, SN refers to the amount to which students have the opportunity to discuss and change their ideas with others (Yu et al., 2022). Jones (2018) discovered that SN significantly contributed to students' CTS. Students in SN collaborate with instructors and peers to choose learning tools and activities. The results of Tang and Chaw's (2016) study showed that students could adapt effectively to the IT environment and foster a feeling of CT when they were in a smart classroom setting.

IL has been defined as the process of learning new things through experimentation and observation (Maor & Fraser, 1996). It emphasises participation and the learner's accountability for discovering previously undiscovered information (Pedaste et al., 2015). According to Harlen (2013), IL enables students to comprehend natural events via the use of cognitive abilities. Students' information literacy and CTS are efficiently developed through IL exercises (Cebrián et al., 2020). Findings from Zubaidah et al. (2017) show that IL enables more effective integration of information literacy material, fostering meaningful learning by promoting reflection, active involvement, and learning, and successfully fostering CTS.

RT stands for the profound, repeated, and active reconceptualization of already-existent concepts (Kurt, 2018). Antonio (2020) states RT is essential for enhancing people's CTS. He said that to foster the abilities to recognize and solve problems, analyse opinions and ideas, synthesise information, and evaluate information—which are typical features of CTS—individuals must identify the problem, choose appropriate information sources, evaluate findings, organise information, and construct new knowledge. RT improves future performance for students by developing their CTS, particularly in a rich information environment (Slade et al., 2019).

The physical environmental aspects of smart classrooms are referred to as FD (MacLeod et al., 2018). The classroom environment, including the furniture, colours, and lighting, is part of the FD to promote student participation (Li et al., 2015). Smart classrooms are meant to provide a wide choice of equipment as well as adaptable classroom spaces that may assist students' learning (Tissenbaum & Slotta, 2019). DeRuisseau (2016) proposed that flipped learning with smart devices might help students with CTS. Thus, students in smart classrooms have more opportunities to collect and evaluate various forms of information.

Researchers hypothesised that students' motivation to embrace a certain technology is directly connected to its PU and EOU (Ross & Gray, 2006). The degree to which people believe technology will increase productivity is called PU. Simultaneously, EOU captures individuals' opinions about how much effort is required to use technology (Hentzen et al., 2022; Ismail et al., 2023). There is a considerable positive link between students' PU and EOU and learning results in the smart learning environment (MacLeod et al., 2018). According to Lu et al. (2021), online attitudes can have a direct impact on students' CTS.

In smart classrooms, a high-bandwidth wireless network may assist students in obtaining diverse resources from various learning terminal devices (Ramlee et al., 2019). This process has students continually judging, comparing, analysing, synthesising, and evaluating various resources to establish their appropriateness for learning information (Paul & Elder, 2020). Students' high-level thinking skills can be efficiently cultivated during this procedure (Fig. 1). Thus, the authors propose the below hypotheses:

H_1: SN is positively associated with CTS among preservice teachers.
H_2: IBL is positively associated with CTS among preservice teachers.
H_3: RT is positively associated with CTS among preservice teachers.
H_4: FD is positively associated with CTS among preservice teachers.
H_5: EOU is positively associated with CTS among preservice teachers.

H$_6$: PU is positively associated with CTS among preservice teachers.
H$_7$: MS is positively associated with CTS among preservice teachers.

2.2 Cognitive Learning Strategies as Moderator

When the CLS is used to influence students' behaviour as desired, learning is successful (Biwer et al., 2020). CLS are strategies that help learners digest information more thoroughly. Significant correlations exist between CLS and learning outcomes, including idea acquisition and cognitive capacity (Siburian et al., 2019). Due to modern technology, students are now utilising CLS more successfully. It has been established that CLS plays a significant part in academic achievement (Sen & Yilmaz, 2016). Learner characteristics like CLS and PSCLE, which have altered in the context of the smart classroom, have an impact on CTS. One of CLASs primary responsibilities is to recognize information coming in from the outside world, analyse it methodically, store it, and correctly classify it (Paul & Elder, 2020). Gong et al. (2020) stated that due to the nature of these learning settings, students' CTS might be directly impacted by CLS in a smart classroom. According to Lee and Choi (2012), students who participated in deep CLS tended to be more engaged in CTS results. A substantial positive link between college students' PSCLE and CLS has been discovered by Lu et al. (2022). In addition to a range of information-processing strategies that help students accomplish a goal, CLS also refers to advanced psychological abilities that let students control their learning and thought (Ahmadi et al., 2013). Thus, the current study was created to evaluate the following hypothesis:

H$_8$: CLS moderates the relationship between smart classroom environment factors and CTS among preservice teachers.

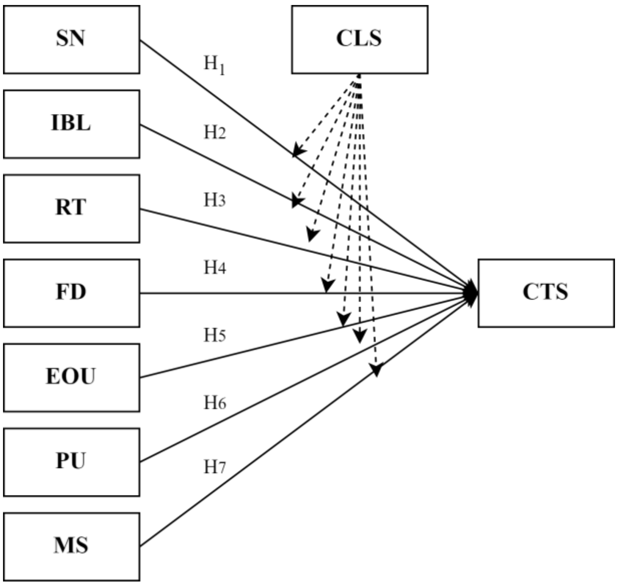

Fig. 1 Conceptual framework.

Note. Critical Thinking Skills=CTS, Student negotiation=SN, Reflective thinking= RT, Functional design=FD, cognitive strategy=CLS, Inquiry-based learning=IBL, Ease of use=EOU, Perceived usefulness=PU, Multiple sources=MS.

3. Materials and Methods

3.1 Research Design

The present study is quantitative in nature. This study's population is preservice teachers, which refers to students enrolled in teacher preparation programmes. The target population is located in Shanxi Province, China. In recent years, to further optimise the teaching environment of colleges and universities, the government of Shanxi Province has promoted the construction of a smart campus 2.0 plan for HE. Four teacher-training institutions are Shanxi Normal University, Taiyuan Normal University, Yuncheng Normal College, and Yuncheng College. According to the information from the academic management departments of these four universities, the total target population is 4040. This study adopted the Cochran (1977) formula to calculate the sample size based on the target population. According to Cochran's (1977) formula, the minimum sample size for this is 350. The preservice teachers were given 725 questionnaires, 39 (5.37%) of which were insufficient for analysis. Consequently, 686 preservice teachers between 19 and 24 made up the study's whole sample. In this study, demographic heterogeneity was addressed using proportionate stratified random sampling. The sample number of each institution is first obtained in this study following the proportion, and then the sample number of preservice teachers from each professional field in these universities, which comprises: Shanxi Normal University (n= 171), Taiyuan Normal University (n= 173), Yuncheng Normal College (n= 171), and Yuncheng College (n= 171).

To ensure the content validity of the questionnaire, first, the researcher selected measurement instruments with high validity in the existing literature. The authors invited a panel of three Chinese experts to evaluate the content validity of the measurement tool. All items of the questionnaires were reviewed and considered acceptable. To avoid errors caused by language expressions, the researcher invited two linguists to translate the questionnaire repeatedly from English to Chinese and then from Chinese to English. Participants were informed that their participation was voluntary, anonymous, and unrelated to their course grades.

3.2 Measurement

Pre-service teachers' preferences regarding other crucial components of the learning environment were assessed using scales from a smart classroom (SC) learning environment preference instrument (MacLeod et al., 2018). The following learning environment aspects were determined to be essential for SCs based on our study of related research: IL, SN, RT, FD, MS, PU, and EOU. Each scale consisted of five items and was measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A sample statement was provided for each item, such as "I can talk with other students about how to conduct research in the interactive classroom". CTS scale was adopted from the California Critical Thinking Disposition Inventory (CCTDI) and a set of items derived from the SF-CTDICV (Hwang et al., 2010) but tailored for college students (Facione & Facione, 1992). All questions are based on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I am a person with logical thinking". Pintrich et al. (1993) developed the Motivated Strategies for Learning Questionnaire (MSLQ), which is a self-report instrument translated into Chinese (Wang et al., 2023). According to the research objectives, this study adopted the sub-scales of cognitive learning strategy (12 items). All items were evaluated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A sample item is "I memorize keywords to remind me of important concepts in this class."

3.3 Data Analysis

The SPSS, v.26.0, was used in this cross sectional design study for descriptive and inferential statistics. To ensure that the assumptions of normality, linearity, and multicollinearity were not violated, preliminary data assays were carried out. The three constructs were described using means and standard deviations. The researchers determined the association between the independent components and the CTS using linear correlation coefficients. Multiple linear regression (MLR) analyses were carried out due to the inference analysis used in this study. The study used multi-group analysis to evaluate the moderating impacts of CLS. Finally, hypothesis testing was done to assess whether or not the suggested hypotheses were valid.

4. Results

4.1 Demographic Results

The sample consisted of 236 (34.4%) males and 450 (65.6%) females with an average age of 21 years (Table 1).

Table 1. Profile of respondents' demographics (n = 686)

Characteristics	Frequency	Percentage	Mean	SD
Age			21	1.19
Field of study				
Chinese Education	159	23.17		
English Education	119	17.35		
Mathematics Education	157	22.88		
Science Education	155	22.60		
Art Education	96	14		

4.2 Preliminary Results

The study assessed the measuring scales' reliability, convergent validity, and discriminant validity to verify the model's characteristics. All factor-loading values were greater than 0.70, indicating sufficient convergent validity for each research construct. All estimates of composite reliability (CR), Cronbach's α, average variance extracted (AVE), and their corresponding cut-off values of 0.7 and 0.5, respectively, were higher (Table 2).

Table 2. Factor loading, mean and standard deviations, reliability, AVEs, and composite reliability of constructs

Constructs	Items	Factors	Mean	SD	α	AVE	CR
CTS					0.78	0.8854	0.9071
PSCLE							
	SN				0.88	0.7660	0.9087
	IL				0.88	0.7671	0.9091
	RT				0.89	0.7125	0.9253
	FD				0.85	0.8495	0.9023
	EOU				0.87	0.8489	0.9371
	PU				0.87	0.8383	0.9238
	MS				0.86	0.8572	0.9093
LS							
	CLS				0.89	0.7586	0.8752

Note. Critical Thinking Skills=CTS, Student negotiation=SN, Reflective thinking= RT, Functional design=FD, cognitive strategy=CLS, Inquiry-based learning=IBL, Ease of use=EOU, Perceived usefulness=PU, Multiple sources=MS.

4.3 Descriptive Results

The first hypothesis of this study aimed to determine the relationship between the perceived value of SPSCLE factors (independent variables) and the preservice teachers' CTS (correlation). The results are shown in Table 4 and depict significant positive relationships between all SPSCLE factors and CTS.

Table 3. Product-moment correlation matrix

No.	Construct	Mean	SD	1	2	3	4	5	6	7
1	CTS	1.41	0.131							
2	SN	3.78	0.699	0.606						
3	RT	3.77	0.694	0.424	.750**					
4	FD	3.90	0.668	0.331	.746**	.765**				
5	IBL	3.74	0.704	0.402	.803**	.815**	.714**			
6	EOU	3.99	0.684	0.469	.685**	.673**	.818**	.625**		
7	PU	3.98	0.634	0.339	.728**	.689**	.824**	.659**	.895**	
8	MS	3.92	0.543	0.424	.739**	.727**	.789**	.697**	.833**	.870**

Note. Critical Thinking Skills=CTS, Student negotiation=SN, Reflective thinking= RT, Functional design=FD, Inquiry-based learning=IBL, Ease of use=EOU, Perceived usefulness=PU, Multiple sources=MS, ** $p < 0.01$.

4.4 Multiple Linear Regression

MLR was performed to assess the predictability of CTS among preservice teachers via the study's independent variables. Four predictors significantly predicted the CTS of preservice teachers in China. The most positive, statistically significant predictor was RT, with $\beta = .249$, $p < .001$. IBL value of $\beta =.157$, $p < .001$, EOU value of $\beta =.124$, $p < 0.05$, and PU value of $\beta =.237$, $p < .001$ indicate significant predictors of preservice teachers' CTS. In short, these results provide statistical evidence for accepting H_2, H_4, H_5, and H_6. The results show that predictor variables explain up to 63.8% of the variance in the CTS, which indicates a medium explanatory power respectively.

Table 4. Research hypotheses linear regression analyses.

Hypotheses	β	Beta	t	Results
SN → CTS	.068	.091	1.822	H_1: NS
RT → CTS	.294***	.390	7.728	H_2: SU
FD → CTS	.054	.070	1.234	H_3: NS
IBL → CTS	.157***	.211	4.110	H_4: SU
EoU → CTS	.124*	.158	2.264	H_5: SU
PU → CTS	.237**	.263	3.286	H_6: SU
MS → CTS	-.018	-.023	-.387	H_7: NS

Note: Not supported= NS, Supported = SU, R^2=.55; *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; R^2= 63.8.

4.5 Moderation Analysis

The independent factors, moderating variable, and interaction term were regressed on the dependent variable in order to examine the moderating impact of CLS. The correlations in Table 5 all have significant values and positive beta values. The beta number, however, clearly shows that the moderator is improving the connection. Consequently, it supports the moderating impact of CLS. Thus, H_8 is accepted.

Table 5. Regression results (Moderator: CLS).

Relationship			Estimate	S.E	C.R.	P	Results
CTS	→	SN	0.239	0.054	4.055	***	
CTS	→	CLS	0.255	0.054	0.442	***	
CTS	→	SN×CLS	0.260	0.044	5.842	***	Supported
CTS	→	RT	0.180	0.052	3.461	***	
CTS	→	CLS	0.220	0.058	3.793	***	
CTS	→	RT×CLS	0.280	0.050	5.600	***	Supported
CTS	→	FD	0.280	0.066	5.757	***	
CTS	→	CLS	0.190	0.044	7.445	***	
CTS	→	FD×CLS	0.320	0.033	12.42	***	Supported
CTS	→	IBL	0.150	0.058	2.585	***	
CTS	→	CLS	0.160	0.052	3.036	***	
CTS	→	IBL×CLS	0.255	0.050	0.240	***	Supported
CTS	→	EOU	0.212	0.031	1.22	***	
CTS	→	CLS	0.234	0.025	0.455	***	
CTS	→	EOU×CLS	0.258	0.029	0.561	***	Supported
CTS	→	PU	0.208	0.051	0.431	***	
CTS	→	CLS	0.221	0.059	0.461	***	
CTS	→	PU×CLS	0.229	0.061	0.556	***	Supported
CTS	→	MS	0.178	0.034	0.661	***	
CTS	→	CLS	0.209	0.053	0.563	***	
CTS	→	MS×CLS	0.220	0.069	0.632	***	Supported

Note. Critical Thinking Skills=CTS, Student negotiation=SN, Reflective thinking= RT, Functional design=FD, cognitive learning strategy=CLS, Inquiry-based learning=IBL, Ease of use=EOU, Perceived usefulness=PU, Multiple sources=MS, df1=1, df2=684. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussion

The main purpose of this study was to examine the impact of the preference of preservice teachers in SCs on their CTS. Given the importance of CTS and the prevalence of SCs in HE. An MLR analysis was used to explore the relationships between the key factors of SPSCLE and CTS. The study proved an association between SPSCLE factors and CTS. This finding is consistent with previous studies that the preferences of students and their interaction with the learning environment are important aspects of the learning process (e.g., Hamutoglu et al., 2020). The study investigated a MLR between study variables. The most significant findings of this study indicate that Preservice teachers' RT, IBL, EOU, and PU significantly affect CTS in the SC in contrast to SN, FD, and MS. Consistent with previous studies, RT is an important factor in developing CTS of preservice teachers (e.g., Mete, 2020). According to Greenberger (2020), RT allows students to examine their cognitive structure and learning activities critically. In a SC environment, students have a strong reflective ability and consciousness. In addition, the results confirmed other studies' findings regarding the predictability of IBL on CTS (Deák et al., 2021). IBL often naturally exposes students to new opportunities for cross-disciplinary collaboration. Wale and Bishaw (2020) held that students as self-directed learners always process information and design their activities.

Moreover, the study confirmed EOU and PU as predictors of CTS, similar to Jiang et al.'s (2022) findings. Sugandini et al. (2021) argued that students are very concerned about the ease of online learning and class discussion sessions in the SC, and they stated that EOU and PU are two factors that affect their desire for learning. A SC is a virtual-real mixed classroom environment combining advanced technologies (Abdul Rahman et al., 2015; Lam & Habil, 2021; Othman et al., 2022). Conversely, the study findings reject the predictability of CTS by SN among preservice teachers in contrast to student studies that prove such likelihood exists in SC environments (e.g., Richards et al., 2020). Besides, SN requires students to listen and analyse the information from others; based on that, they reflect on their judgments, enrich their knowledge with others ' viewpoints (Malm et al., 2020). For this reason, to investigate why the SN of Chinese preservice teachers does not lead to CTS, other factors, such as the cultural factors should be investigated by prospect studies.

The findings also failed to support that FD predicts CTS as hypothesised by previous studies (e.g., Liu et al., 2021). According to the awakening view of environmental psychology, environmental stimulation will awaken people's psychological or behavioural responses to a certain extent. In contrast, positive environmental stimulation will improve people's work quality (Honebein & Reigeluth, 2020). However, further studies are needed to investigate the FD of SCs in the researched Chinese universities and how well they meet the approved standards. According to Kasperiuniene and Tandzegolskiene (2020), diverse learning resources help learners to develop CTS. SCs combine classic teaching and online platforms (Kang & Zhang, 2023). In future studies, researchers should re-examine why SC does not promote CTS in the eyes of preservice teachers in other circumstances despite heavy investment in Chinese universities.

The findings provide implications for developing CTS in smart learning environments. Specifically, preservice teachers' CTS are developed based on aspects of their preferences that need more attention from instructors and institutions. Besides, to solve problems effectively, learners need to adopt effective CLS to perceive and utilise the opportunities provided by the smart learning environment to engage in practical problem-solving actions. Therefore, in the process of cultivating CTS, universities should value and support SPSCLE and encourage students to use high–level CLS to complete some complex learning tasks.

6. Limitations

Several limitations existed in this study. First, this is a cross-sectional research design in which the causal explanation is not included; hence only restricted explanations concerning the study's constructs have been produced. Second, data were collected by self-report measures. Because of participants' answer bias, a self-report questionnaire may have inherent limitations in survey results. To counteract this, the respondent's anonymity was safeguarded, which minimised assessment anxiety. Third, only Chinese students were included in the sample. Therefore, care must be used when applying the findings outside this target population. Fourth, the generalisation of the results is limited to Chinese universities in Shanxi Province, China. Moreover, due to the nature of quantitative studies, future research may consider using other methods, such as longitudinal studies to identify the nature and antecedents of CTS. Fifth, the analysis of the moderating role of CLS as examined in this study. Future studies should seek other potential moderators. Finally, sex-based differentiation has not been studied, as it falls outside the scope and objectives of this article.

7. Conclusion

The study's findings increase our understanding of crucial elements influencing preservice teachers' CTS in SCs. The findings can improve preservice teachers' CTS by informing instructional practices. Briefly, the results indicate that to develop CTS, policy-makers should consider students' RT, IBL, EOU, and PU toward the SC when analysing, designing, developing, implementing, and evaluating learning activities in a SC. The insights gained from the study can play a valuable role in enhancing the CTS of preservice teachers. This suggests that by taking into account the information obtained from the study, educators and institutions can take steps to better prepare and support future teachers in their ability to effectively teach science content. In summary, the conclusion highlights that the study's findings enhance our understanding of what affects preservice teachers' confidence and ability to teach science content. These findings can be used to improve teaching practices by incorporating the identified factors, and policymakers should take these factors into account when shaping education policies related to science classroom activities.

8. Co-Author Contribution

The authors affirmed that there is no conflict of interest in this article. carried out the field work, prepared the literature review and overlooked the writeup of the whole article. Author 2 wrote the research methodology and did the data entry. Author 3& 4 carried out the statistical analysis and interpretation of the results.

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