

Developing the Smart Classroom Environment Model to Enhance Innovative Thinking and Digital Literacy

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Abstract

This research aims to 1) study the current state of learning environments that promote innovative thinking and digital literacy, 2) develop the SCID Model for smart classrooms, 3) examine the model's effectiveness, and 4) evaluate and validate the model through expert review. The study is conducted in four phases: Phase 1 involves surveying the existing learning environment; Phase 2 focuses on developing the SCID Model and research tools; Phase 3 implements the model with students; and Phase 4 evaluates and validates the model. The research sample comprises 245 faculty members from Northeast Rajabhat Universities, seven educational technology experts, seven research instrument specialists, six expert panel members, and 23 undergraduate students enrolled in the Technology and Innovation for Learning course. Research tools include a learning environment questionnaire, in-depth interviews, the SCID Model, implementation tests, assessments of innovative thinking and digital literacy, and a satisfaction survey. Data analysis employs frequency, percentage, mean, standard deviation, dependent t-tests, and content analysis for qualitative data. Results reveal that the current smart classroom environments face significant challenges in physical, psychological, social, and technological aspects, with the highest demand for improvement. The developed SCID Model comprises input factors (physical environment), a learning process (psychological, social, technological environments), outputs (digital literacy skills), and outcomes (innovative thinking skills). Implementation showed significant improvements in students' skills at the 0.05 level, with high satisfaction. Expert validation found 33.33% confirmed model completeness, while 66.66% suggested refinements.

Keywords: smart classroom model, innovative thinking, digital literacy

1. Introduction

Rapid advancements in information and communication technology have significantly impacted the education system. These changes demand a learning environment that not only focuses on academic knowledge but also fosters essential 21st-century skills such as innovative thinking and digital literacy, which are crucial for learners to adapt and succeed in an ever-changing world (Li et al., 2025; Corrêa & Mourão, 2025). In Thailand, national policies support the development of these competencies, including the National Digital Development Plan for Economy and Society (2015-2025), which aims to utilize digital technology to improve infrastructure, innovation, data management, human capital, and other resources to promote digital opportunities and equity (Ministry of Information and Communication Technology, 2016). In addition, the National Education Act B.E. 1999 (amended) and the Higher Education Act B.E. 2019 emphasize the importance of using technology in higher education to enhance learner skills and prepare them for lifelong learning. An essential factor supporting these skills development is the learning environment, which should include four key components: physical, psychological, social, and technological. A balanced integration of these elements helps create an adequate learning space that supports students' cognitive, emotional, and collaborative development (Detyna, Ogunbase & Briffa, 2025; Cavadas & Correia, 2022). The concept of a smart classroom offers a promising approach to developing 21st-century skills by integrating technology with interactive and adaptable teaching methods. Smart classrooms provide diverse learning experiences that better meet students' needs compared to traditional classrooms. They also promote self-directed learning and encourage the use of technology for analytical thinking

and creative problem-solving (Setiamurti & Kurniawati, 2024). Moreover, innovative thinking goes beyond thinking outside the box—it involves generating new ideas that can solve real-life problems, a critical skill in today's competitive job market. Similarly, digital literacy is not merely about operating technology but also the ability to evaluate and manage information effectively (Makhafola & Subaveerapandiyan, 2025; Kreuder, Döring & Kowalski, 2024). Therefore, designing learning experiences that integrate technology into the educational process is increasingly necessary. Accordingly, this research aims to explore the design of a smart classroom environment that promotes innovative thinking and digital literacy among undergraduate students. The study considers all four dimensions—physical, psychological, social, and technological—to develop a practical and contextually relevant model for digital-era education, ultimately preparing students for success in the 21st century.

2. Method

2.1 Research Objectives

- To study the components and current state of intelligent classroom environments and related theories that support innovative thinking and digital literacy.
- To develop a thoughtful classroom environment model that enhances innovative thinking and digital literacy.
- To examine the effects of implementing the innovative classroom environment model.
- To evaluate and validate the innovative classroom environment model.

2.2 Research Procedures

Phase 1: Study the components and current state of smart classroom environments and related theories.

Phase 2: Develop the model and research instruments.

Phase 3: Implement the smart classroom environment model.

Phase 4: Evaluate and validate the smart classroom environment model.

2.3 Population and Sample

- Study of Components, Current State, and Needs for Smart Classroom Environments

Population: 2,674 faculty members from the Faculty of Education at Rajabhat Universities nationwide.

Sample: 245 faculty members from the Faculty of Education at Northeast Rajabhat Universities were selected through simple random sampling.

- Implementation of the Smart Classroom Environment Model

Population: 312 first-year undergraduate students from the Faculty of Education, Nakhon Ratchasima Rajabhat University.

Sample: 23 first-year students from the Physical Education program, selected through simple random sampling, enrolled in the Technology and Innovation for Learning course.

2.4 Research Instruments

- Learning Environment Questionnaire: This questionnaire consists of 48 items covering four aspects: physical environment, psychological environment, social environment, and technological environment. Three experts validated the questionnaire, which has an Index of Item-Objective Congruence (IOC) ranging from 0.66 to 1.00.

- Smart Classroom Environment Model for Enhancing Innovative Thinking and Digital Literacy

This model was evaluated by seven experts, with the overall assessment indicating a high level of suitability.

- Learning Achievement Test: This test comprises 50 multiple-choice questions with four answer choices. The test's efficiency was assessed with 50 students enrolled in the "Innovation and Technology for Learning" course during the first semester of the 2022 academic year. The test difficulty index (p) ranged from 0.26 to 0.78, the discrimination index (r) ranged from 0.20 to 0.60, and the overall reliability coefficient was 0.85.

- Innovative Thinking Skills Assessment: This assessment consists of 20 items covering five aspects: unlocking, stimulation, questioning for differentiation, providing diverse information, and exchanging relevant experiences. Three experts validated the questionnaire with an IOC ranging from 0.66 to 1.00.

- Digital Literacy Skills Assessment: This assessment consists of 24 items covering six aspects: understanding, usage, creation, evaluation, safety, and sharing. Three experts validated the questionnaire with an IOC ranging from 0.66 to 1.00.

• **Satisfaction Assessment of the Model Implementation:** This assessment consists of 44 items covering five aspects: physical environment, psychological environment, social environment, technological environment, and instructional management. Three experts validated the questionnaire with an IOC ranging from 0.66 to 1.00.

2.5 Data Analysis

Statistical analysis included frequency, percentage, mean, standard deviation, and dependent t-test. The questionnaire results were interpreted using the following mean score criteria : 0-1.50 = Very low, 1.51-2.50 = Low, 2.51-3.50 = Moderate, 3.51-4.50 = High, 4.51-5.00 = Very high Qualitative data were analyzed using content analysis.

2.6 Ethical Considerations

The Mahasarakham University Ethics Committee for Research Involving Human Subjects (No. 287-302/2023, issued on 27 July 2023) approved this research study. All data were kept confidential.

3. Results

3.1 Current Conditions, Needs, and Components of the Smart Classroom Environment for Enhancing Innovative Thinking and Digital Literacy

The survey respondents comprised 245 faculty members from the faculties of education at Rajabhat University in the northeastern region of Thailand. The respondents' educational qualifications were as follows: 184 respondents (75.10%) held a master's degree, and 61 respondents (24.90%) held a doctoral degree. Regarding teaching experience: 22 respondents (8.98%) had 0-4 years of experience. Eighty-four respondents (34.29%) had 5-10 years of experience. One hundred thirty-nine respondents (56.73%) had more than 10 years of experience. The results are summarized in Table 1.

Table 1. Faculty Members' Opinions on the Current State, Needs, and Components of the Smart Classroom Environment for Enhancing Innovative Thinking and Digital Literacy

Aspect	Current Condition (Mean)	S.D.	Interpretation	Needs (Mean)	S.D.	Interpretation	PNI
Physical Environment	3.57	0.88	High	4.59	0.60	Very High	0.286
Psychological Environment	3.78	0.81	High	4.53	0.64	Very High	0.198
Social Environment	3.87	0.80	High	4.47	0.66	High	0.155
Technological Environment	3.76	0.89	High	4.68	0.46	Very High	0.245
Instructional Process	4.01	0.72	High	4.64	0.50	Very High	0.157
Assessment	3.87	0.82	High	4.51	0.60	Very High	0.165
Overall	3.81	0.82	High	4.57	0.57	Very High	0.201

Table 1 summarizes the questionnaire on instructors' opinions regarding the current state and desired environment of a smart classroom that promotes innovative thinking and digital literacy. Overall, the current state is rated at a high level ($M = 3.81$, $S.D. = 0.82$). Meanwhile, the desired level is rated at the highest level ($M = 4.57$, $S.D. = 0.58$), with a PNI of 0.201, indicating a reasonable level.

3.2 Results of Developing a Smart Classroom Environment Model to Promote Innovative Thinking and Digital Literacy

The Smart Classroom Environment Model for promoting Innovative Thinking and Digital Literacy (SCID Model) aims to foster innovative thinking and digital literacy. It consists of five main components.

Input - Things to prepare and analyze before organizing learning, including, Learning Environment Analysis: Analyzed in four dimensions: Physical (the real physical environment): Technological (technologies used in the classroom): Mental Image (learners' imagination and mindset): Society (surrounding social and cultural context)

Learner Analysis: Study of learners' skills, interests, and needs. **Set Course Objectives:** Define what learners should gain (e.g., digital skills, innovative thinking, etc.). **Make a Lesson Plan:** Design lesson plans, activities, and teaching methods. **Learning Activities:** Define activities that align with objectives and context. **Assessment:** Plan for both formative and summative assessments throughout and after learning.

Process - The actual implementation process in the classroom, which includes: Create a Learning Atmosphere : Arrange an appropriate, engaging, and thought-supportive environment. Presenting Content and Teaching Media:

Select suitable digital media and technologies. Discussion and Summary of Content: Encourage learners to discuss, exchange ideas, and co-summarize knowledge.

Output - Immediate outcomes from learning activities: Digital Literacy: Ability to access, use, analyze, and evaluate digital information effectively.

Outcome - The ultimate goal: Innovative Thinking: Learners are able to think creatively, outside the box, and solve new problems independently.

Feedback - A reflection and improvement process: Collect feedback from learners. Teacher self-assessment to analyze and improve future lessons

Key Features of the Model: This model emphasizes analyzing the learning environment and learner characteristics before designing instruction. It integrates technology, society, and learning activities, and includes a systematic feedback mechanism for continuous improvement. The model focuses on achieving two clear outcome areas: Digital Literacy and Innovative Thinking, as illustrated in Figure 1.

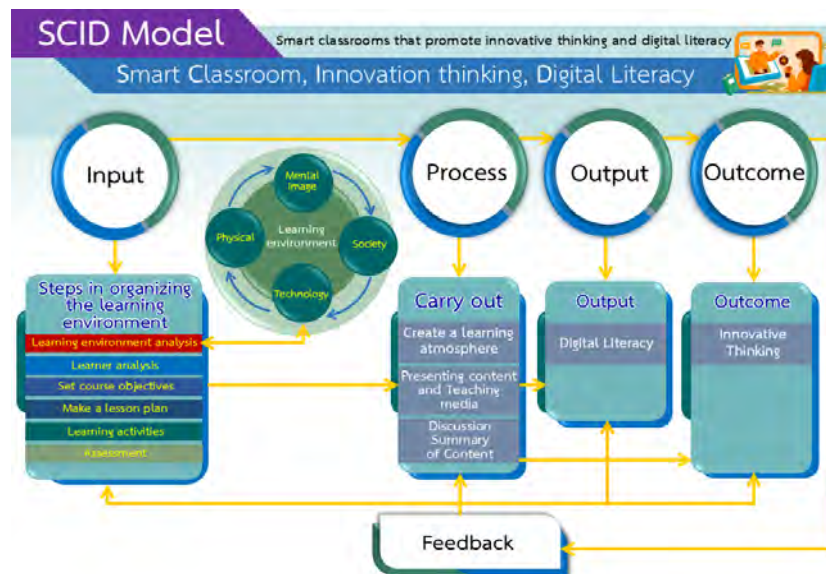


Figure 1. The Smart Classroom Model for Enhancing Innovative Thinking and Digital Literacy (SCID Model)

As shown in Figure 1, the overall components of the model were rated at a high level (M = 4.49, S.D. = 0.78). When evaluating a model's suitability by examining individual components, some aspects were of the highest quality, indicating a strong foundation for the overall model's effectiveness. These include the alignment of components with theories and principles of a bright classroom environment that promotes innovative thinking and digital literacy, the interrelationship of elements, and the comprehensiveness of the model in addressing a thoughtful classroom environment that fosters innovative thinking and digital literacy for students at Rajabhat University. The alignment of input factors, processes, and outcomes, along with their interconnectedness, is a key aspect of high-performing systems that helps understand how teams and processes function and achieve effectiveness.

3.3 Results of Implementing the Smart Classroom Environment Model to Promote Innovative Thinking and Digital Literacy

3.3.1 Comparison of Students' Learning Achievement

The researcher compared the learning achievements of 23 students enrolled in the *Technology and Innovation for Learning* course. The results are in Table 2.

Table 2. Comparison of Learning Achievement of Students in the Course *Technology and Innovation for Learning*

Item	n	Full Score	M	S.D.	df	t-test*	Sig.
Before Learning	23	50	13.61	5.29	22	10.20	0.000
After Learning	23	50	26.96	6.87			

*p<.05

Table 2 shows that the academic achievement of students enrolled in the course "Technology and Innovation for Learning" showed an average pre-test score of 13.61 with a standard deviation of 5.29. After completing the course, the average post-test score increased to 26.96 with a standard deviation of 6.87. A t-test comparison of pre-test and post-test scores indicated that the post-test scores were significantly higher at the 0.05 level.

3.3.2 Assessment of Students' Innovative Thinking Skills

The researcher assessed students' innovative thinking skills using the Smart Classroom Environment Model, designed to promote creative thinking and digital literacy. The results are presented in Table 3.

Table 3. Assessment of Students' Individual Innovative Thinking Skills

Evaluation Criteria	Excellent (5)	Very Good (4)	Good (3)	Fair (2)	Needs Improvement (1)
1. Unlocking Potential	4	8	8	3	-
2. Stimulation	4	9	7	3	-
3. Questioning for Differentiation	5	9	8	2	-
4. Providing Diverse Information	6	10	5	2	-
5. Transforming Related Experiences	7	10	5	1	-

From Table 3, it was found that individual innovative thinking skills improved after using the model as follows: **Unlocking Potential:** 4 students were at the excellent level, eight at every good level, eight at the suitable level, and three at the fair level. **Stimulation:** 4 students were at the outstanding level, nine at the very good level, seven at the suitable level, and three at the fair level. **Questioning for Differentiation:** 5 students were at the excellent level, nine at the very good level, eight at the good level, and two at the fair level. **Providing Diverse Information:** 6 students were at the excellent level, 10 at the perfect level, five at the suitable level, and two at the fair level.

Transforming Related Experiences: 7 students were at the excellent level, 10 at the perfect level, five at the suitable level, and one at the fair level.

3.3.3 Evaluation Results of Students' Digital Literacy Skills

The researcher evaluated students' digital literacy skills using the Smart Classroom Environment Model to promote innovative thinking and digital literacy. The results are presented in Table 4.

Table 4. shows the evaluation results of students' individual digital literacy skills:

Evaluation Criteria	Excellent (5) (Number of People)	Very Good (4) (Number of People)	Good (3) (Number of People)	Fair (2) (Number of People)	Needs Improvement (1) (Number of People)
After Using the Model					
1. Understand	18	2	3	-	-
2. Use	17	3	3	-	-
3. Create	14	5	4	-	-
4. Assess	8	10	4	1	-
5. Safe	10	9	3	1	-
6. Share	9	6	5	3	-

Table 4 shows that students' digital literacy skills after using the model show development in the following levels: **Understand:** eighteen students rated excellent, two students rated very good, and three students rated good. **Use:** seventeen students rated excellent, three students rated very good, and three students rated good. **Create:** fourteen students rated excellent, five students rated very good, and four students rated good.

Assess: eight students rated excellent, ten students rated very good, four students rated good, and one student rated fair. **Safe:** ten students rated excellent, nine students rated very good, three students rated good, and one student rated fair. **Share:** students rated excellent, six rated very good, five students rated good, and three students rated fair.

3.3.4 Evaluation of Students' Satisfaction

The researcher evaluated students' satisfaction with the Smart Classroom Environment Model, which promotes innovative thinking and digital literacy for students at Rajabhat University. The results are presented in Table 5.

Table 5. Student Satisfaction with the Smart Classroom Environment Model that Promotes Innovative Thinking and Digital Literacy

Item	Satisfaction Level	M	S.D.	Interpretation
1. Physical Environment	Most	4.58	0.53	Most
2. Psychological Environment	Most	4.61	0.51	Most
3. Social Environment	Most	4.62	0.50	Most
4. Technological Environment	Most	4.63	0.55	Most
5. Instructional Management	Most	4.69	0.50	Most
Overall	Most	4.63	0.52	Most

From Table 5, it can be seen that students have the highest satisfaction in various aspects of the environment, as follows: Physical environment had an average score at the highest level ($M = 4.58$, $S.D. = 0.53$), Psychological environment had an average score at the highest level ($M = 4.61$, $S.D. = 0.51$), Social environment had an average score at the highest level ($M = 4.62$, $S.D. = 0.50$), Technological environment had an average score at the highest level ($M = 4.63$, $S.D. = 0.55$), and Instructional management had an average score at the highest level ($M = 4.69$, $S.D. = 0.50$). Therefore, overall student satisfaction with the Smart Classroom Environment Model that promotes innovative thinking and digital literacy is at the highest level with an average score of ($M = 4.63$, $S.D. = 0.52$).

3.4 Assessment Results for Validating the Smart Classroom Environment Model that Promotes Innovative Thinking and Digital Literacy

Six experts evaluated the Smart Classroom Environment Model, which promotes innovative thinking and digital literacy for students at Rajabhat University. The results are presented in Table 6.

Table 6. Evaluation Results from Experts to Validate the Smart Classroom Environment Model that Promotes Innovative Thinking and Digital Literacy.

Item	Appropriateness Level	M	S.D.	Interpretation
1. Principles, Concepts, and Objectives	Good	4.33	0.82	Good
2. Model Components in Terms of Inputs	Excellent	4.54	0.57	Excellent
3. Appropriateness of the Environmental Setup Process	Good	4.33	0.81	Good
4. Appropriateness of the Environmental Outcomes	Good	4.33	0.51	Good
5. Overall Model	Excellent	4.59	0.74	Excellent

Table 6 shows that the Principles, Concepts, and Objectives of the model ($M = 4.33$, $S.D. = 0.82$) were evaluated as "Good." For the components of the model, the Inputs ($M = 4.54$, $S.D. = 0.57$) were rated as "Excellent," the Appropriateness of the Environmental Setup Process ($M = 4.33$, $S.D. = 0.81$) was rated as "Good," the Appropriateness of the Environmental Outcomes ($M = 4.33$, $S.D. = 0.51$) was rated as "Good." The Overall Model ($M = 4.59$, $S.D. = 0.74$) was rated "Excellent." In summary, the assessment of the model by the experts concluded that the Smart Classroom Environment Model promoting innovative thinking and digital literacy is deemed appropriate by two experts (33.33%). Four experts (66.66%) agreed that the model is suitable but should be improved based on recommendations to apply it to real-world learning contexts.

4. Discussion of Results

This study focused on developing a smart classroom environment model to promote innovative thinking and digital literacy among students at Rajabhat University. The findings can be discussed in four main aspects: (1) investigation of components, current conditions, and needs; (2) development of the innovative classroom environment model; (3) implementation of the model; and (4) evaluation and validation of the model.

- Investigation of Components, Current Conditions, and Needs. The study identified four key components of an innovative classroom environment: physical, psychological, social, and technological. Each element is crucial in supporting learning that fosters innovation and digital literacy. The physical dimension should include flexible, comfortable spaces supporting diverse learning activities. The psychological dimension emphasizes creating a friendly atmosphere to reduce stress and enhance learning motivation. The social dimension focuses on collaborative learning strategies to develop teamwork skills. Lastly, the technological dimension highlights the integration of digital tools to support interactive and personalized learning experiences. These findings align with

Makhafola & Subaveerapandiyani (2025), who emphasized integrating physical and digital elements to create effective learning environments.

- **Development of the Smart Classroom Environment Model.** The proposed model, SCID (Smart Classroom for Innovative Thinking and Digital Literacy), was developed based on expert input and theoretical frameworks. Experts validated it as a practical tool for enhancing teaching and learning effectiveness. According to Ertmer & Ottenbreit-Leftwich (2010), effective use of technology in education depends largely on teachers' confidence and competence. Therefore, the model emphasizes teacher readiness alongside student engagement. By allowing active participation from learners and integrating technology into instruction, the model supports creative thinking and the development of digital skills. This is consistent with Amabile (1983), who argued that supportive environments are essential for fostering creativity.

- **Implementation of the Model.** Results from the implementation phase showed a significant improvement in students' innovative thinking and digital literacy. These results are supported by Li et al. (2025), who found a causal relationship between digital literacy and academic achievement. Additionally, comparing learning outcomes before and after implementing the model revealed increased students' ability to think innovatively and utilize technology effectively. This finding supports Li & Yu (2025), who emphasized that collaborative learning combined with digital tools enhances problem-solving and critical thinking skills—key competencies required in the 21st century.

- **Evaluation and Validation of the Model.** Experts evaluated and confirmed the SCID model as suitable and of high quality for application in higher education settings. Its design promotes innovative thinking and digital literacy and prepares students for future challenges. One of the key advantages of the model is its adaptability across different educational contexts. This aligns with Morachat & Seechaliao (2024), who demonstrated that technology-based flipped learning models significantly improve digital literacy and student satisfaction. The flexibility and comprehensive approach of the SCID model make it a valuable framework for enhancing 21st-century skills in various educational institutions.

5. Summary of the Research

This research demonstrates that the developed Smart Classroom Environment Model (SCID Model) can effectively promote students' innovative thinking and digital literacy. Designing a flexible and appropriate learning environment helps students confidently adapt to technology and learning processes in the digital age.

The main components of the SCID Model include:

1. Input - Supportive elements such as technology, personnel, and teaching materials.
2. Process - Teaching methods that emphasize participation and the use of technology.
3. Output - Student achievements in terms of increased knowledge and skills.
4. Outcome - Long-term impacts, such as the ability to apply knowledge.
5. Feedback - Ongoing assessment and improvement to enhance the effectiveness of the model.

6. Conclusion

Developing a smart classroom environment model that promotes innovative thinking and digital literacy within the context of Rajabhat Universities has proven an effective strategy for improving educational quality. By integrating the four core components and leveraging technology, this model contributes to the holistic development of essential 21st-century skills. Moreover, its adaptability makes it a promising solution for broader implementation across higher education institutions in the digital age.

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Authors contributions

Kitigorn Tipnad, the researcher, launched the research project, collected and analyzed the data, and drafted the manuscript. Associate Professor Dr. Pachoen Kidrakarn supervised the research project, edited and revised the final manuscript.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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