

The Development of Learning with Digital Technology Smart Learning Through Professional Learning Communities to Enhance Learning Design for Teacher-Professional Students

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Abstract

This research aimed to: (1) develop a Smart Learning model based on digital technology and professional learning communities (PLCs) to enhance instructional design competencies for pre-service teachers; (2) compare pre-service teachers' digital technology (Smart Learning: SL) skills before and after the implementation; and (3) examine students' satisfaction with the developed model. This study employed a Research and Development (R&D) approach integrating quantitative and qualitative methods. The sample consisted of 30 fourth-year pre-service teachers majoring in Computer Education, Faculty of Education, Naresuan University, selected by purposive sampling. The research instruments included lesson plans, an expert evaluation form, a digital technology skill assessment, a classroom observation form, and a satisfaction questionnaire. Data were analyzed using mean, standard deviation, percentage, and dependent t-test, along with content analysis for qualitative data.

The findings revealed that: (1) the developed Smart Learning model, consisting of five core components innovative pedagogy, PLC-based instructional management, technological competence, smart classroom environment design, and digital competency assessment was rated at the highest level of appropriateness; (2) pre-service teachers' digital technology skills after the implementation were significantly higher than before at the .05 level; and (3) overall student satisfaction with the model was at the highest level. This study contributes new knowledge through the development of the Digital- PLC Smart Learning Model and the Technological Pedagogical Design Thinking framework, which integrates digital

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technology, instructional design, and collaborative learning processes to enhance teacher professional competencies in the digital age.

Keywords: Digital Technology; Smart Learning; Professional Learning Community; Constructivist Learning Design

Introduction

The modern world is undergoing rapid and multidimensional transformation driven by digital technology, which has significantly reshaped educational systems and learning processes. Digital learning platforms have emerged as key mechanisms enabling smart learning through the integration of knowledge systems, digital information, and interactive technologies. These platforms support flexible and personalized learning, allowing learners to develop competencies aligned with 21st-century demands, including self-directed learning, digital literacy, and lifelong learning (Hai, et al., 2021). In this context, educational institutions are increasingly required to adopt innovative approaches that integrate digital tools, artificial intelligence (AI), and online learning environments to enhance learning effectiveness and accessibility.

Despite these advancements, significant challenges remain in the development of instructional design competencies among pre-service teachers, particularly in the effective integration of digital technology into teaching practices. In many teacher education programs, students often possess basic technological skills but lack the ability to apply these tools systematically in designing meaningful and learner-centered learning experiences. This problem is particularly evident in higher education institutions, where instructional design still tends to rely on traditional approaches, with limited emphasis on collaborative learning, reflective practice, and technology-enhanced pedagogy (Stoll, et al., 2006; Seufert, et al., 2018). As a result, pre-service teachers may not be adequately prepared to design and implement innovative learning activities that respond effectively to the demands of the digital age.

Previous studies have emphasized the importance of professional learning communities (PLCs) and digital technology integration in enhancing teacher competencies (Stoll, et al., 2006; Seufert, et al., 2018). However, most existing research has focused on either digital technology skills or collaborative learning

processes separately, with limited attention to their integration within a systematic instructional design framework. Recent studies have begun to explore the role of PLCs in supporting digital teaching competencies; nevertheless, these studies still tend to examine specific aspects of digital integration rather than developing comprehensive instructional models (Liu, et al., 2024; Mishra, et al., 2023). Furthermore, there remains a lack of empirical research that develops and validates integrated models combining smart learning, digital technology, and PLCs specifically for pre-service teachers. This indicates a clear research gap in developing a comprehensive and practical framework that can effectively enhance instructional design competencies through the integration of these key elements.

Therefore, this study aims to develop and evaluate a Smart Learning model based on digital technology and professional learning communities (PLCs) to enhance instructional design competencies for pre-service teachers. Specifically, the study focuses on (1) developing the instructional innovation and (2) implementing and evaluating its effectiveness, including pre-service teachers' digital technology skills and student satisfaction.

This study is designed to address the identified research gap by integrating smart learning, digital technology, and PLCs into a comprehensive instructional framework for pre-service teachers. The findings are expected to contribute to both theoretical and practical advancements in instructional design and teacher education, particularly in the context of digital transformation.

Research Objectives

1. To develop an instructional innovation based on smart learning through professional learning communities (PLCs) to enhance learning management for pre-service teachers.
2. To implement and evaluate the effectiveness of learning management using smart learning innovation through PLCs among pre-service teachers who have participated in digital technology-based smart learning activities.

Research Methodology

This research was conducted as a Research and Development (R&D) study to develop a Smart Learning model through digital technology and professional

learning communities (PLCs) to enhance instructional design for pre-service teachers. The research methodology consisted of the following stages:

1. Documentary Research

The researcher studied related concepts, theories, and previous research on digital technology, smart learning, instructional design, and professional learning communities in order to synthesize the conceptual framework and identify the core components of the developed model.

2. Research and Development

Based on the synthesized framework, the Smart Learning model was designed and developed. The development process included literature review, model drafting, design of learning activities, construction of research instruments, and validation of the model by experts. The sample in this phase consisted of 9 experts in digital technology, teaching methodology, and education, selected by purposive sampling. The instrument used in this phase was an expert evaluation form for appropriateness of the model. Data were analyzed by mean and standard deviation.

3. Quantitative Research

The developed model was implemented with 30 fourth-year pre-service teachers majoring in Computer Education, Faculty of Education, Naresuan University, who were enrolled in the Computer Instructional Methodology course in the first semester of the 2025 academic year. The sample was selected by purposive sampling. The research instruments included lesson plans, a digital technology skill assessment form, and a student satisfaction questionnaire. Data were analyzed using mean, standard deviation, percentage, and dependent t-test.

4. Qualitative Research

Qualitative data were collected through classroom observation and expert review in order to examine the appropriateness and effectiveness of the developed Smart Learning model in real instructional settings. The instruments used included a classroom observation form and structured expert evaluation form. The qualitative findings were used to support the interpretation of the quantitative results.

Results

The findings of this study are presented in alignment with the research objectives as follows.

1. To develop an instructional innovation based on smart learning through professional learning communities (PLCs) to enhance learning management for pre-service teachers.

The findings revealed that the developed Smart Learning instructional innovation consists of five systematically interconnected components: (1) knowledge and skills in innovative pedagogy and classroom psychology, (2) instructional management using smart learning through PLCs, (3) technological competence in emerging technologies, (4) smart classroom environment design, and (5) assessment and evaluation of digital learning competencies.

Dimension	Summary
Knowledge and content	Knowledge/content, methods, digital technology, interaction
Instructional strategies	Use of new technology, interaction
Practical skills	Smart Learning, AI tools, distance teaching
Teaching approaches	Learning design, PLC collaboration
Evaluation	Digital technology competencies, Smart Learning skills

Table 1 Key Synthesized Components of the Instructional Design for the Smart Learning Model through Digital Technology and Professional Learning Communities

Table 1 shows that the five components are not independent but are functionally integrated within a sequential instructional process. The process begins with the development of pedagogical knowledge, which provides the conceptual foundation for instructional design. This is followed by instructional management through PLC-based collaboration, where learners engage in knowledge sharing, peer discussion, and reflective practice. These collaborative processes act as the core mechanism that facilitates the development of technological competence. Learners then apply digital tools in designing smart classroom environments, and finally, assessment and evaluation provide feedback for continuous improvement of instructional practices. This demonstrates that PLC functions as a central mechanism linking all components, enabling a systematic process that enhances instructional design competencies among pre-service teachers.

2. To implement and evaluate the effectiveness of learning management using smart learning innovation through PLCs among pre-service teachers.

The results indicated that pre-service teachers' digital technology skills after participating in the Smart Learning innovation were significantly higher than before the implementation at the .05 level of statistical significance.

2.1 Learning Outcomes

The results indicated that pre-service teachers' digital technology skills after participating in the Smart Learning innovation were significantly higher than before the implementation at the .05 level of statistical significance.

Measure	N	Mean	S.D.
Pre-test	30	19.8667	3.6553
Post-test	30	38.9333	0.9803
Difference	30	19.0667	3.6097

Table 2 Comparison of Pre-test and Post-test Scores

Table 2 indicates that the mean score increased from 19.87 (S.D.=3.66) in the pre-test to 38.93 (S.D.=0.98) in the post-test, reflecting a substantial improvement in learners' digital technology skills. In addition, the reduction in standard deviation suggests that learners demonstrated more consistent competency levels after the intervention.

The dependent t-test analysis confirmed that the post-test scores were significantly higher than the pre-test scores ($t=28.931$, $p < .001$), indicating the effectiveness of the Smart Learning innovation in enhancing digital competencies. However, it should be noted that this study employed a one-group pretest-posttest design, which may limit internal validity. The observed improvement may be partially influenced by testing effects or maturation effects, rather than solely by the intervention. Therefore, the findings should be interpreted with caution, and future studies should consider more rigorous experimental designs to strengthen causal inference.

2.2 Student Satisfaction

The results showed that overall student satisfaction with the Smart Learning innovation through professional learning communities was at the highest level.

No.	Evaluation Aspect	Mean	S.D.	Level
1	Instructor	4.91	0.13	Highest
2	Content	4.95	0.09	Highest
3	Digital activities	4.55	0.35	Highest
4	Media and tools	4.87	0.27	Highest
5	Assessment	4.92	0.10	Highest
6	Learners	4.81	0.19	Highest
Overall		4.83	0.10	Highest

Table 3 Student Satisfaction with the Smart Learning Model through Professional Learning Communities

Table 3 indicates that all dimensions of satisfaction were rated at the highest level. However, the relatively high mean scores and low standard deviation suggest that responses are highly concentrated at the upper level, which may indicate potential response bias, such as social desirability or contextual influence during data collection. Therefore, the findings should be interpreted with caution.

Discussion

1. Development of the Smart Learning Instructional Innovation

The findings of this study revealed that the developed Smart Learning instructional innovation based on digital technology and professional learning communities (PLCs) consists of five systematically interconnected components, including innovative pedagogical knowledge, PLC-based instructional management, technological competence, smart classroom environment design, and digital competency assessment. These components function as a coherent instructional process rather than isolated elements, indicating that instructional design competencies can be effectively enhanced through the systematic integration of pedagogy, technology, and collaborative learning within a structured instructional framework.

This finding may be explained by the role of PLCs as a central instructional mechanism that facilitates collaboration, knowledge sharing, and reflective practice among learners. Through these processes, pre-service teachers are able to co-construct knowledge, exchange ideas, and refine instructional designs, leading to deeper professional learning. In addition, digital technology supports flexible learning

environments, access to diverse learning resources, and interactive learning processes, which are essential characteristics of smart learning environments. This is consistent with Stoll, et al. (2006), who emphasized that PLCs promote shared learning and continuous professional development, and aligns with the Technological Pedagogical Content Knowledge (TPACK) framework (Herring, et al., 2016), which highlights the integration of technological, pedagogical, and content knowledge for effective teaching. Therefore, the contribution of this finding lies in demonstrating how PLC and TPACK concepts can be operationalized within a Smart Learning instructional innovation to enhance instructional design competencies for pre-service teachers.

2. Effectiveness of the Smart Learning Instructional Innovation

The findings indicated that the implementation of the Smart Learning instructional innovation was effective in improving pre-service teachers' digital technology skills and resulted in a high level of student satisfaction. The significant increase in post-test scores compared to pre-test scores suggests that learners developed stronger digital competencies after participating in the instructional activities, reflecting the effectiveness of the instructional process in enhancing learning outcomes.

This improvement may be attributed to the learning process, which emphasizes active learning, collaborative learning, and the application of digital tools in authentic contexts. These characteristics are consistent with constructivist learning theory, which posits that learners construct knowledge through experience, interaction, and reflection. In addition, the use of PLCs provides opportunities for collaborative problem-solving and reflective dialogue, which further strengthens instructional integration and professional learning. This is supported by Liu, et al. (2024), who found that PLCs enhance digital teaching competencies and instructional integration.

Furthermore, the high level of student satisfaction indicates that the instructional innovation effectively supports learner engagement, motivation, and learning management. This may be explained by the integration of digital technology, artificial intelligence, collaborative learning processes, and learner-centered instructional design, which together create a flexible and engaging learning environment. However, the interpretation of these findings should be approached with caution. The use of a one-group pretest–posttest design may limit internal

validity, as the observed improvement may be influenced by testing effects or maturation effects. Moreover, the high concentration of satisfaction scores at the upper level, along with low standard deviations, may indicate potential response bias or contextual influences during data collection.

The contribution of this finding is both theoretical and practical. Theoretically, the study demonstrates how the integration of smart learning, digital technology, and PLCs can function as a systematic instructional mechanism for enhancing digital competencies. Practically, the findings provide a guideline for designing learning activities that promote digital competence, instructional design skills, and collaborative professional learning among pre-service teachers in the digital age.

New Knowledge

This research contributed new knowledge in the field of instructional design and teacher professional development in the digital age by developing a Smart Learning model through digital technology and professional learning communities (PLCs). The new body of knowledge derived from this study can be summarized into three main aspects.

First, this research developed a new instructional process model called the Digital- PLC Smart Learning Model, which integrates digital technology, artificial intelligence, and professional learning communities into instructional design. This model emphasizes collaborative learning, reflective practice, and the use of digital tools to support instructional planning and learning management. The model helps pre-service teachers transition from technology users to instructional designers who can effectively integrate digital technology into teaching and learning processes.

Second, this research proposed a new competency framework called Technological Pedagogical Design Thinking, which combines technological knowledge, pedagogical knowledge, and instructional design thinking. This competency framework focuses on the ability of teachers to analyze learning problems, select appropriate digital tools, design learning activities, and evaluate learning outcomes using digital technology. This framework extends the concept of Technological Pedagogical Content Knowledge (TPACK) by emphasizing design thinking and smart learning environments.

Third, this research provides a practical guideline for implementing smart learning through professional learning communities in teacher education programs.

The guideline includes collaborative lesson design, peer observation, reflective discussion, and the integration of digital platforms for knowledge sharing. This approach supports continuous professional development and helps create a sustainable learning community for teachers in the digital era.

In summary, the new knowledge gained from this research is the integration of smart learning, digital technology, and professional learning communities into a systematic instructional design model that can be used to develop instructional design competencies for pre-service teachers and improve learning management in the digital age.

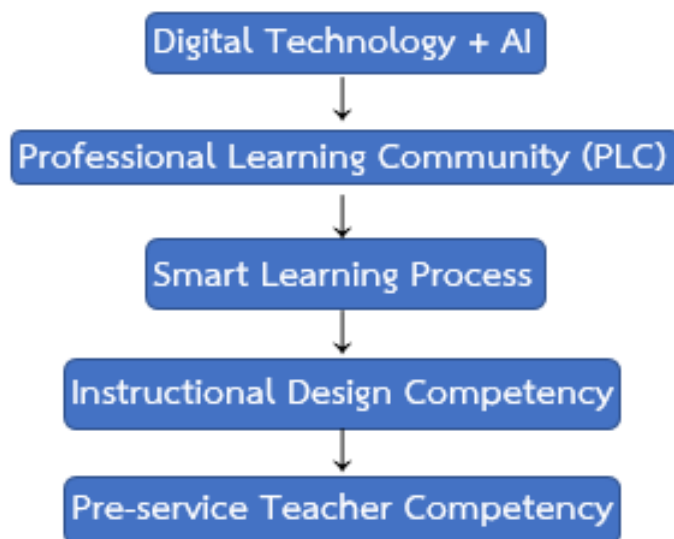


Figure 1 The New Knowledge

Conclusion and Suggestion

This research aimed to develop a Smart Learning model through digital technology and professional learning communities (PLCs) to enhance instructional design competencies for pre-service teachers. The results showed that the developed Smart Learning model was highly appropriate and effective for instructional design development. The model consisted of five core components: innovative pedagogy, instructional management through PLCs, technological competence, smart classroom environment design, and digital competency assessment. The implementation of the model significantly improved pre-service teachers' digital technology skills at the .05 level of statistical significance, and student satisfaction with the learning model was

at the highest level. These findings indicate that the integration of digital technology and professional learning communities can effectively enhance instructional design competencies and support learning management in the digital age. Therefore, the Smart Learning model can be applied as an instructional innovation for developing instructional design competencies and digital teaching skills among pre-service teachers.

1. Policy Recommendations

1.1 Educational institutions should promote the integration of digital technology and professional learning communities in teacher education programs to enhance instructional design competencies for pre-service teachers.

1.2 Educational policy makers should support the development of smart learning environments, including digital infrastructure, learning platforms, and professional learning communities for teachers.

1.3 Teacher development policies should emphasize digital competency, instructional design skills, and collaborative learning processes to prepare teachers for the digital education era.

2. Practical Recommendations

2.1 Teacher education programs should implement the Smart Learning model through professional learning communities to enhance instructional design competencies for pre-service teachers.

2.2 Instructors should integrate digital technology, artificial intelligence, and online learning platforms into instructional design and learning management.

2.3 Professional learning communities should be established to encourage collaboration, knowledge sharing, and reflective practice among teachers and pre-service teachers.

3. Future Research Recommendations

3.1 Future research should investigate the long-term effects of the Smart Learning model on teaching performance and instructional design competencies of pre-service teachers during their teaching practicum.

3.2 Future studies should examine the application of the Smart Learning model in different subject areas and educational levels.

3.3 Comparative studies should be conducted between traditional instructional methods and smart learning approaches to evaluate differences in learning outcomes and instructional design competencies.

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