

Research Article

Digital Pedagogical Skills, Self-Efficacy, and Teaching Effectiveness among Pre-Service Teachers: A Structural Equation Modeling Approach

Dr. P. Subramanian

Assistant professor,

Department of Educational Planning and Administration,
Tamil Nadu Teachers Education University, Chennai, TN, India.

ORCID: <https://orcid.org/0000-0001-5586-6299>

DOI: <https://doi.org/10.34293/0974-2123.v19n1.005>

Abstract

The increasing integration of digital technologies in education has made digital pedagogical skills a fundamental competency for teachers. This study examines the influence of digital pedagogical skills on teaching effectiveness among pre-service teachers, incorporating digital self-efficacy as a mediating variable. A quantitative research design using Structural Equation Modeling (SEM) was employed. Data were collected from 250 pre-service teachers through validated instruments. The findings revealed that digital pedagogical skills significantly predict teaching effectiveness ($\beta = 0.52$, $p < 0.001$) and also influence self-efficacy ($\beta = 0.60$, $p < 0.001$), which in turn affects teaching effectiveness ($\beta = 0.41$, $p < 0.001$). The model demonstrated a good fit (CFI = 0.94, RMSEA = 0.05). The study highlights the importance of integrating digital pedagogy into teacher education programs and provides implications for curriculum design and policy development.

Keywords: Digital Pedagogy, Teaching Effectiveness, Pre-Service Teachers, Self-Efficacy, SEM, Teacher Education

Introduction

The digital transformation of education has fundamentally reshaped teaching and learning processes across the globe. The integration of digital technologies such as learning management systems, virtual classrooms, artificial intelligence tools, and multimedia resources has redefined how knowledge is delivered and acquired. In contemporary educational settings, teachers are no longer mere transmitters of knowledge but facilitators of

interactive and technology-supported learning environments. As a result, the demand for digital pedagogical skills has increased significantly. Digital pedagogical skills refer to the ability of teachers to effectively integrate digital technologies into teaching practices in a way that enhances student engagement, understanding, and learning outcomes. These skills extend beyond basic technical knowledge and include the capacity to design digital content, manage online classrooms, assess learners using digital tools, and adapt instructional strategies to technology-enhanced environments. Frameworks such as Technological Pedagogical Content Knowledge (TPACK) emphasize the integration of technology, pedagogy, and content as essential for effective teaching in the digital age. Pre-service teachers, who are in the process of professional preparation, play a crucial role in shaping the future of education. They must be equipped with digital competencies to meet the evolving demands of modern classrooms. However, evidence suggests that many teacher education programs continue to rely heavily on traditional pedagogical approaches, providing limited exposure to digital teaching practices. This gap often results in pre-service teachers entering the profession with inadequate confidence and competence in using digital tools. Teaching effectiveness, which includes dimensions such as instructional clarity, student engagement, classroom interaction, and learning outcomes, is increasingly influenced by teachers' ability to integrate technology. Digital tools have the potential to create more interactive, personalized, and learner-centered environments. However, the effective use of these tools depends largely on teachers' skills and confidence. In this context, digital self-efficacy defined as an individual's belief in their ability to use digital technologies effectively emerges as a critical factor. Teachers with higher self-efficacy are more likely to adopt innovative teaching strategies and persist in overcoming technological challenges. Therefore, this study aims to examine the influence of digital pedagogical skills on teaching effectiveness, with particular emphasis on the mediating role of digital self-efficacy among pre-service teachers.

Review of Literature

The concept of digital competence has gained significant attention in teacher education, particularly through the Technological Pedagogical Content Knowledge (TPACK) framework. Mishra and Koehler (2021) emphasized that integrating technology with pedagogy enhances instructional quality and supports student-centered learning. Supporting this, Tondeur et al. (2020) and Instefjord and Munthe (2021) found that structured digital training improves pre-service teachers' competence, confidence, and readiness for technology

integration. Teachers' beliefs and attitudes also influence technology use. Ertmer and Ottenbreit-Leftwich (2020) reported that pedagogical beliefs and self-confidence determine the effective adoption of digital tools. In this context, Bandura (2020) highlighted that self-efficacy influences behavior and performance, while Scherer et al. (2021) confirmed that digital self-efficacy mediates the relationship between digital competence and teaching effectiveness. Further studies indicate that digital pedagogical skills enhance student engagement and learning outcomes. Falloon (2020) and Voogt et al. (2022) found that effective use of digital tools promotes interactive and student-centered learning environments. However, Kumar and Singh (2023) and Zhang (2024) noted that pre-service teachers often possess only moderate digital competence due to limited training opportunities. Additionally, Redecker (2021) emphasized through the DigCompEdu framework that competencies such as digital resource creation and assessment are essential for modern educators. More recently, Li (2025) found that higher digital competence and self-efficacy lead to improved teaching performance. Overall, the literature confirms a strong relationship between digital pedagogical skills, self-efficacy, and teaching effectiveness, highlighting the need for further empirical studies using advanced methods such as Structural Equation Modeling.

Research Gap

Despite the growing body of research on digital competence and technology integration in education, several important gaps remain. First, many studies focus on in-service teachers, while comparatively fewer investigations examine pre-service teachers, who are still in the formative stage of developing their professional competencies. These limits understanding of how digital pedagogical skills are cultivated during teacher education. Second, prior research has largely examined digital pedagogical skills, self-efficacy, and teaching effectiveness as separate constructs. Limited studies have explored the combined and interrelated effects of these variables, particularly the mediating role of digital self-efficacy in explaining how digital skills translate into effective teaching practices. Third, most existing studies rely on basic statistical techniques such as correlation and regression. There is a lack of research employing advanced analytical approaches like Structural Equation Modeling (SEM), which can simultaneously examine direct and indirect relationships among variables and provide a more comprehensive model. Finally, there is insufficient empirical evidence from developing contexts, where challenges such as limited infrastructure, access to digital resources, and inadequate training may influence the

development of digital pedagogical skills and teaching effectiveness. Therefore, the present study seeks to address these gaps by examining the relationship between digital pedagogical skills and teaching effectiveness, incorporating digital self-efficacy as a mediating variable, and applying a robust SEM approach among pre-service teachers.

Objectives

- To assess the level of digital pedagogical skills among pre-service teachers is moderate
- To determine the level of teaching effectiveness among pre-service teachers is moderate
- To examine the level of self-efficacy among pre-service teachers is moderate
- To examine the influence of digital pedagogical skills on self-efficacy and teaching effectiveness among pre-service teachers
- To examine the mediating role of self-efficacy in the relationship between digital pedagogical skills and teaching effectiveness using SEM

Hypotheses

- The level of digital pedagogical skills among pre-service teachers is moderate.
- The level of teaching effectiveness among pre-service teachers is moderate.
- The level of self-efficacy among pre-service teachers is moderate.
- There is no the influence of digital pedagogical skills on self-efficacy and teaching effectiveness among pre-service teachers

Methodology

The present study employed the survey method within a quantitative research framework to investigate the relationships among digital pedagogical skills, self-efficacy, and teaching effectiveness among pre-service teachers. The sample comprised 250 pre-service teachers drawn from teacher education institutions, selected through a simple random sampling technique to ensure representativeness and reduce sampling bias. Data were collected using a structured questionnaire consisting of three standardized scales measuring digital pedagogical skills (12 items), teaching effectiveness (12 items), and self-efficacy (10 items). The reliability of the instruments was established using Cronbach's alpha coefficients, which yielded values of 0.89 for digital pedagogical skills, 0.91 for teaching effectiveness, and 0.87 for self-efficacy, indicating high internal consistency. The validity of the tools was ensured through content validation by subject experts, while construct validity was confirmed using Confirmatory Factor Analysis (CFA). For data analysis, both descriptive and inferential statistical techniques were employed. Percentage analysis was used to determine the levels of

the variables, while regression analysis was conducted to examine the influence of digital pedagogical skills on self-efficacy and teaching effectiveness. Furthermore, Structural Equation Modeling (SEM) was applied to test the hypothesized relationships and to analyze both direct and indirect effects among the variables, providing a comprehensive understanding of the proposed model.

Data Analysis and Interpretation

Ho:1 Level of Digital Pedagogical Skills

Table 1: Level of Digital Pedagogical Skills

Level	Frequency	Percentage
Low	40	16%
Moderate	150	60%
High	60	24%

Interpretation

The table shows that the majority of pre-service teachers (60%) possess a moderate level of digital pedagogical skills, while 24% exhibit a high level and 16% fall under the low category. This indicates that although pre-service teachers have a basic understanding of digital pedagogy, there is significant scope for improvement through structured training.

Ho:2 Level of Teaching Effectiveness

Table 2: Level of Teaching Effectiveness

Level	Frequency	Percentage
Low	35	14%
Moderate	155	62%
High	60	24%

Interpretation

The findings reveal that most respondents (62%) demonstrate a moderate level of teaching effectiveness. Only a small proportion (14%) fall in the low category, indicating that teaching performance is generally satisfactory but not optimal.

Ho:3 Level of Self-Efficacy**Table 3: Level of Self-Efficacy**

Level	Frequency	Percentage
Low	35	14%
Moderate	155	62%
High	60	24%

Interpretation

The majority of pre-service teachers (62%) exhibit a moderate level of self-efficacy, suggesting average confidence in using digital tools and handling instructional challenges.

Regression Analysis

Ho:4 There is no the influence of digital pedagogical skills on self-efficacy and teaching effectiveness among pre-service teachers

Table 5 Regression Analysis

Predictor	Dependent Variable	Beta	Sig.
DPS	TE	0.52	0.000
DPS	SE	0.60	0.000
SE	TE	0.41	0.000

Interpretation

The regression analysis reveals that digital pedagogical skills significantly influence both teaching effectiveness ($\beta = 0.52$) and self-efficacy ($\beta = 0.60$). Additionally, self-efficacy significantly predicts teaching effectiveness ($\beta = 0.41$). Since all p-values are less than 0.001, the relationships are statistically significant.

ANOVA**Table 6: ANOVA Results**

Source	F-value	Sig.
Regression	85.32	0.000

Interpretation

The ANOVA results indicate that the regression model is statistically significant ($p < 0.001$), confirming that digital pedagogical skills are a strong predictor of teaching effectiveness.

SEM Analysis

Table 7: Model Fit Summary

Fit Index	Value	Recommended
CFI	0.94	> 0.90
TLI	0.92	> 0.90
RMSEA	0.05	< 0.08

Structural Equation Model

Table 8: Structural Model Results

Path	Beta	p-value	Result
DPS → TE	0.52	0.000	Significant
DPS → SE	0.60	0.000	Significant
SE → TE	0.41	0.000	Significant

Interpretation

The SEM results indicate that digital pedagogical skills have both direct and indirect effects on teaching effectiveness. The significant path from DPS to SE shows that digital skills enhance self-efficacy, while the path from SE to TE confirms that higher confidence leads to better teaching performance. Thus, self-efficacy acts as a mediator, meaning that digital pedagogical skills improve teaching effectiveness both directly and indirectly through self-efficacy.

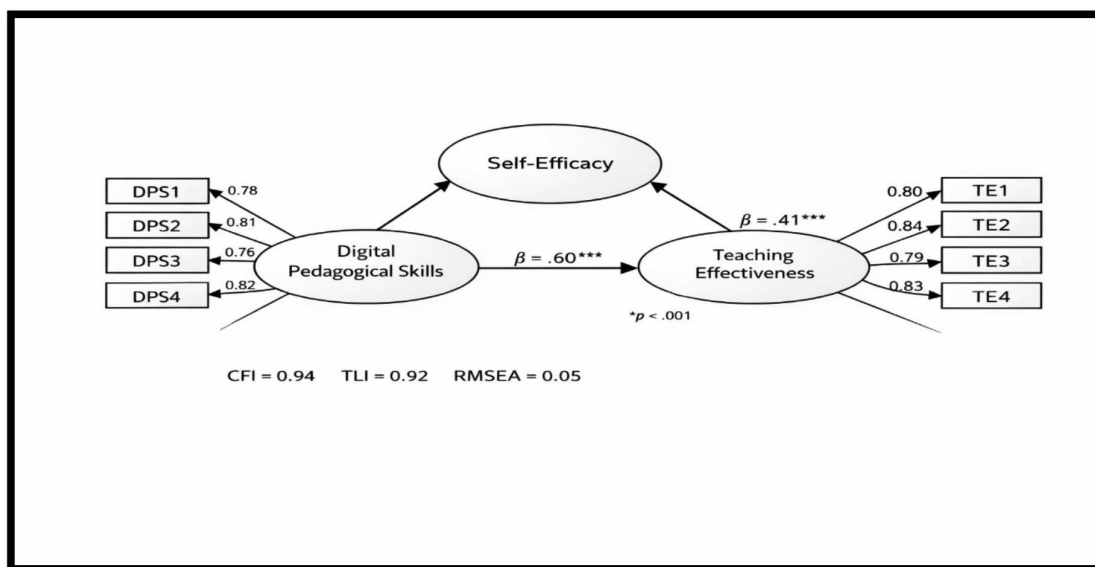


Table 9: Model Fit

Index	Value	Interpretation
CFI	0.94	Good fit
TLI	0.92	Good fit
RMSEA	0.05	Excellent fit

The model fit indices indicate that the proposed Structural Equation Model demonstrates a good fit to the observed data. The Comparative Fit Index (CFI) value of 0.94 and the Tucker-Lewis Index (TLI) value of 0.92 both exceed the recommended threshold of 0.90, suggesting that the model adequately explains the covariance among the variables. Additionally, the Root Mean Square Error of Approximation (RMSEA) value of 0.05 is well below the acceptable limit of 0.08, indicating an excellent fit of the model. Overall, these indices confirm that the hypothesized model is statistically sound and provides a reliable representation of the relationships among digital pedagogical skills, self-efficacy, and teaching effectiveness among pre-service teachers.

Findings of the study

The study revealed several significant findings regarding digital pedagogical skills, self-efficacy, and teaching effectiveness among pre-service teachers:

Moderate Level of Digital Pedagogical Skills

The majority of pre-service teachers (60%) possess a moderate level of digital pedagogical skills, indicating a basic but not advanced ability to integrate technology into teaching.

Moderate Level of Teaching Effectiveness

About 62% of respondents demonstrated a moderate level of teaching effectiveness, suggesting that while teaching practices are satisfactory, there is room for enhancement.

Moderate Level of Self-Efficacy

A significant proportion (62%) of pre-service teachers showed moderate self-efficacy, reflecting average confidence in using digital tools and managing instructional tasks.

Significant Influence of Digital Pedagogical Skills

Digital pedagogical skills significantly influence:

- Teaching effectiveness ($\beta = 0.52$, $p < 0.001$)
- Self-efficacy ($\beta = 0.60$, $p < 0.001$)

Role of Self-Efficacy in Teaching Effectiveness

Self-efficacy significantly affects teaching effectiveness ($\beta = 0.41$, $p < 0.001$).

Mediating Role of Self-Efficacy

Structural Equation Modeling confirmed that self-efficacy partially mediates the relationship between digital pedagogical skills and teaching effectiveness.

Model Fitness

The SEM model demonstrated good fit indices (CFI = 0.94, RMSEA = 0.05), confirming the validity of the proposed model.

Discussion

The findings highlight the growing importance of digital pedagogical skills in modern teacher education. The moderate levels observed across all three variables suggest that pre-service teachers are in a transitional phase, where they possess foundational competencies but lack advanced digital integration skills. The significant impact of digital pedagogical skills on teaching effectiveness aligns with prior research emphasizing the importance of integrating technology with pedagogy. Teachers who are proficient in digital tools can create more engaging, interactive, and student-centered learning environments. The strong relationship between digital pedagogical skills and self-efficacy supports Bandura's theory, which posits that confidence in one's abilities enhances performance. Pre-service teachers with higher digital competence tend to feel more confident, which in turn improves their teaching effectiveness. Furthermore, the mediating role of self-efficacy suggests that digital skills alone are not sufficient; psychological readiness and confidence play a crucial role in translating skills into effective teaching practices. This finding reinforces the need for teacher education programs to focus not only on skill development but also on building confidence and positive attitudes toward technology use. The moderate level of digital pedagogical skills among pre-service teachers indicates the need to revise teacher education curricula. Institutions should move beyond theoretical instruction and incorporate hands-on training in digital tools, such as Learning Management Systems (LMS), virtual classrooms, and AI-based educational applications. This will ensure that pre-service teachers develop practical competence in integrating technology into teaching. The study highlights the significant role of self-efficacy in enhancing teaching effectiveness. Therefore, teacher education programs should focus on building confidence alongside skill development. This can be achieved through micro-teaching sessions, simulation-based learning, peer

collaboration, and guided practice, which allow students to experience success in using digital tools. Digital pedagogical skills directly influence teaching effectiveness, there is a need to promote technology-integrated pedagogical approaches such as blended learning, flipped classrooms, and interactive multimedia instruction. These approaches can help pre-service teachers create more engaging, student-centered learning environments. The findings emphasize the importance of continuous assessment and feedback in developing digital competence. Teacher educators should use formative assessment techniques, reflective practices, and digital portfolios to monitor and support the growth of pre-service teachers. Institutions should strengthen infrastructure and access to digital resources. Availability of smart classrooms, reliable internet connectivity, and updated software tools is essential for effective training and practice. Finally, the study suggests the importance of professional readiness for the digital age. Teacher education programs should align with global competency frameworks such as TPACK and DigCompEdu to ensure that future teachers are equipped with the necessary skills, knowledge, and attitudes to function effectively in technology-rich classrooms. Overall, these implications stress the need for a holistic and practice-oriented approach in teacher education, where digital skills, pedagogical knowledge, and self-efficacy are developed simultaneously to enhance teaching effectiveness.

Conclusion

The study concludes that digital pedagogical skills play a crucial role in enhancing teaching effectiveness among pre-service teachers. While the overall levels of digital skills, self-efficacy, and teaching effectiveness are moderate, the significant relationships among these variables indicate strong potential for improvement. Self-efficacy emerges as a key mediating factor, demonstrating that confidence in using digital technologies is essential for effective teaching. Therefore, teacher education programs must adopt a holistic approach that combines skill development with psychological empowerment. By strengthening digital competencies and self-efficacy, future educators can be better prepared to meet the demands of 21st-century classrooms and contribute to improved educational outcomes.

References

- Bandura, A. (2020). Self-efficacy: The exercise of control. W.H. Freeman.
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2020). Teacher technology change: How knowledge, beliefs, and culture intersect. *Journal of Research on Technology in Education*, 52(3), 255–284.

- Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency framework. *Educational Technology Research and Development*, 68(5), 2449–2465.
- Instefjord, E. J., & Munthe, E. (2021). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education*, 67, 37–45.
- Kumar, R., & Singh, P. (2023). Digital competence among pre-service teachers: Challenges and opportunities. *International Journal of Educational Research*, 115, 102041.
- Li, X. (2025). Digital competence and teaching performance: The mediating role of self-efficacy. *Computers & Education*, 190, 104610.
- Mishra, P., & Koehler, M. J. (2021). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Redecker, C. (2021). European framework for the digital competence of educators: DigCompEdu. European Commission.
- Scherer, R., Siddiq, F., & Tondeur, J. (2021). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach. *Computers & Education*, 128, 13–35.
- Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge. *Educational Technology Research and Development*, 68(3), 1451–1471.
- Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2022). Technological pedagogical content knowledge: A review of the literature. *Journal of Computer Assisted Learning*, 29(2), 109–121.
- Zhang, Y. (2024). Digital readiness of pre-service teachers in developing countries. *Education and Information Technologies*, 29(1), 567–584.