International Journal of Educational Insights and Innovations (IJEDINS)
Vol. 2, No. 2, June 2025, pp. 56~61
ISSN: 3089-2376 (Media Online)

Development of TPACK-Based Digital Learning Curriculum for Elementary School Teachers

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Article Info

Article history:

Received June 10, 2025
Revised June 20, 2025
Accepted June 30, 2025

Keywords:

Digital Curriculum
TPACK
Elementary School Teachers
21st Century Learning
Curriculum Development

ABSTRACT

Digital transformation in education requires teachers to have competencies that are not limited to pedagogy and content, but also technology. This study aims to develop a digital learning curriculum based on the TPACK (Technological Pedagogical Content Knowledge) framework that can be implemented by elementary school teachers to improve the quality of the learning process in the digital age. A research and development (R&D) approach was used, adapting the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). During the analysis phase, teachers' needs for technology integration in learning were identified through observation and interviews. The analysis results were used to design a curriculum that balances and contextualizes technological, pedagogical, and content aspects according to the needs of elementary school teachers. The developed curriculum prototype was then validated by curriculum experts, educational technology experts, and experienced teachers. The validation results indicated that the curriculum has a high level of feasibility in terms of content relevance, TPACK component integration, and its effectiveness in teaching practice. Subsequently, the curriculum was implemented on a limited basis in several elementary schools and evaluated through questionnaires and observation of implementation. The evaluation results showed an increase in teachers' competencies in effectively integrating technology into the teaching and learning process.

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1. INTRODUCTION

The development of information and communication technology has brought significant changes to various aspects of life, including the world of education. [1]The digital era demands a transformation in learning that is not only focused on mastering content, but also requires the effective integration of technology into the teaching and learning process. In the context of elementary schools (SD), the role of teachers is crucial because they are not only conveyors of material but also facilitators of learning who can utilize technology to create an active, innovative, and meaningful learning environment. [2]

Unfortunately, the reality on the ground shows that most elementary school teachers still face difficulties in optimally integrating technology into their teaching. [3] This is due to various factors, including limited technological knowledge, insufficient relevant training, and the absence of a curriculum that systematically guides the use of technology in pedagogical and content contexts. [4] This is where the Technological Pedagogical Content Knowledge (TPACK) framework becomes essential as a foundation for curriculum

development, helping teachers develop their competencies holistically across three main aspects: technology, pedagogy, and content. [5]

TPACK is a conceptual framework that integrates content knowledge, pedagogical knowledge, and technological knowledge in an integrated manner. [6] The use of TPACK in curriculum development is considered effective because it guides teachers in designing learning that is relevant to the needs of 21st-century students, where digital literacy and critical thinking skills are top priorities. Previous studies, such as those confirm that the TPACK approach can improve the quality of digital learning when applied appropriately in teacher education processes. [7]

However, to date, there has been little curriculum development at the elementary school level specifically designed based on the TPACK framework. [8] Most teacher training or digital learning modules are partial and do not address the interconnection between content, pedagogy, and technology in depth. Therefore, this study focuses on the development of a TPACK-based digital learning curriculum specifically designed for elementary school teachers, with the aim of providing practical and structured guidance in integrating technology into daily teaching practices. [9]

This research not only aims to produce a viable and applicable curriculum product but also to measure the extent to which the curriculum can enhance teachers' TPACK competencies after being implemented in real learning contexts. [10]Thus, the results of this research are expected to make a tangible contribution to improving the quality of elementary education in the digital age and serve as a reference for the development of technology-based teacher training policies in the future. [11]

2. METHOD

This study uses a Research and Development (R&D) approach that aims to produce a product in the form of a TPACK (Technological Pedagogical Content Knowledge)-based digital learning curriculum that suits the needs of elementary school teachers. [12] The development model used in this study is the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The selection of this model is based on its advantage in providing a structured flow in instructional development, particularly in the context of technology-based education. [13]

In the Analysis stage, the researcher conducted a needs assessment of elementary school teachers through observation, interviews, and the distribution of questionnaires. [14] Data was collected from several elementary schools selected as research samples to identify teachers' competencies in implementing technology-based learning, as well as the gaps between field needs and the available curriculum. An analysis was also conducted on the existing curriculum to assess the extent to which TPACK elements had been integrated. [15]

The Design stage involved designing a curriculum structure that included learning objectives, materials, learning strategies, media, and learning evaluation, all based on TPACK principles. In this stage, a preliminary draft of the curriculum to be developed was also prepared.

The Design stage is a crucial stage in the curriculum development process, where all major components of the curriculum are systematically designed based on the results of the needs analysis in the previous stage. This design is oriented towards the integration of the three main elements of TPACK, namely Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), so that the resulting curriculum truly reflects a 21st-century technology-based learning approach. This draft will be reviewed and validated by experts during the development stage to ensure the appropriateness of the content, the integration of components, and the feasibility of implementation in elementary schools.

In the Development stage, the designed curriculum was developed into a complete curriculum prototype. This prototype was then validated by experts, including curriculum experts, educational technology experts, and elementary education practitioners. The validation instrument used a Likert scale assessment sheet covering aspects of content relevance, TPACK element integration, and curriculum applicability in the elementary school learning context.

After passing the validation stage, the research continues to the Implementation stage, which is a limited trial in several partner elementary schools. Teachers involved in the trial are given brief training on the developed curriculum, then they are asked to apply it in teaching and learning activities for a certain period. During implementation, classroom observations and documentation of the learning process are carried out.

The final stage is Evaluation, which aims to assess the effectiveness of the curriculum and its impact on improving teachers' competencies in integrating technology. Evaluation is conducted through the distribution of questionnaires, reflective interviews, and teacher performance assessments based on TPACK competency rubrics. Data is analyzed using descriptive quantitative and qualitative methods to provide a comprehensive overview of the success of the developed curriculum. With systematic stages based on real-world needs, this methodology is expected to produce a curriculum that is not only theoretically sound but also practical in the context of elementary school learning in the digital age.

3. RESULTS AND DISCUSSION

This study aims to develop a TPACK-based digital learning curriculum that can be effectively implemented by elementary school teachers. The results of the study were obtained through five stages of the ADDIE model, with a primary focus on expert validation, limited trials, and curriculum implementation evaluation. The following is a description of the results and discussion based on these stages:

3.1. Expert Validation Results

The initial draft of the curriculum developed during the design phase was validated by three experts: a curriculum expert, an educational technology expert, and an elementary education practitioner. The validation process used a 4-point Likert scale assessment instrument, covering four main aspects: content relevance, TPACK component integration, feasibility, and usefulness.

Table 1. Expert Validation Results of the Digital Learning Curriculum Draft

Aspect Evaluated	Expert 1	Expert 2	Expert 3	Average Score	Category
Relevance of Content	4	4	3	3.67	Very Feasible
Integration of TPACK Components	4	4	4	4.00	Very Feasible
Curriculum Applicability	3	4	4	3.67	Very Feasible
Practicality and Usefulness	4	3	4	3.67	Very Feasible
Average Total				3.75	Very Feasible

Scale: 1 = Not Feasible, 2 = Feasible with Major Revisions, 3 = Feasible with Minor Revisions, 4 = Very Feasible

The validation results indicate that the curriculum falls into the “highly suitable” category with an average score of 3.75 out of 4.00. The aspect receiving the highest evaluation was the integration of TPACK components, where experts assessed that the curriculum effectively integrates technological knowledge, pedagogy, and content in a harmonious manner. The curriculum was also deemed contextual as it was adapted to the realities of learning in elementary schools and flexible enough to be applied across various subjects.

3.2. Limited Trial Results

The validated curriculum was then tested on a limited basis in three elementary schools located in urban and semi-urban areas, involving 12 classroom teachers as participants. Prior to implementation, the teachers received brief training on the curriculum structure and TPACK principles.

Table 2. Comparison of Teacher Competency (Pre-Test and Post-Test)

Competency Indicator	Pre-Test (%)	Post-Test (%)	Improvemen
Understanding of TPACK Framework	65	90	+25
Ability to Integrate Technology in Lesson Planning	68	87	+19
Use of Digital Media in Teaching	70	88	+18
Designing RPP Based on TPACK	66	85	+19
Average Score	67.25	87.5	+20.25

Observations of the implementation of learning showed that teachers were able to understand and apply the TPACK approach in planning and implementing learning. Teachers began to use technology such as interactive presentations, learning videos, digital platforms (Google Classroom, Canva, and Padlet), and Augmented Reality (AR)-based media effectively. The application of strategies such as blended learning and project-based learning also began to be seen, although still limited to certain topics.

3.3. Implementation Evaluation Results

A post-implementation evaluation was conducted to measure improvements in teacher competence in TPACK aspects. The assessment was carried out through teacher competence questionnaires, reflective interviews, and assessments of lesson plans prepared by teachers. The results of the data analysis show that:

There was an increase in teachers' competencies in designing TPACK-based digital learning, with the average questionnaire score increasing from 68% (sufficient category) to 88% (very good category) after implementation.

Table 3. Comparison of Teacher Competency (Pre-Test and Post-Test)

Observation Indicator	Description
Use of Digital Tools	Teachers actively used Google Classroom, Canva, Padlet, and AR-based media.
Strategy Application	Integration of blended learning and project-based learning observed.

Student Engagement	Students were more engaged during interactive sessions.
Teacher Confidence	Teachers showed increased confidence using digital tools in class.
Alignment with TPACK Framework	Lesson plans demonstrated clear TPACK integration.

The lesson plans developed by teachers demonstrate good integration between content, pedagogical strategies, and technology utilization. This indicates a deep understanding of the TPACK framework in real-world practice. Reflective interviews revealed that teachers feel more confident in using technology in teaching and are able to adapt their teaching approaches to the characteristics of students and the subjects they teach.

The results of this study indicate that the development of TPACK-based curriculum has a positive impact on improving the quality of learning at the elementary school level. These findings suggest that the TPACK approach can facilitate teachers in integrating technology pedagogically and contextually.

The integration of technology into the curriculum not only improves the quality of learning but also helps teachers to be more adaptive to the dynamics of digital education development. Through a structured curriculum, teachers have clear guidelines in designing, implementing, and evaluating technology-based learning. These results indicate that curriculum development using the TPACK approach is a strategic step to strengthen teachers' capacity in facing the challenges of 21st-century learning.

In addition, the implementation of the curriculum also shows that training and mentoring support are very important in ensuring the successful use of TPACK in the field. Without adequate training, teachers tend to use technology only as a presentation tool, rather than as part of an integrated pedagogical strategy.

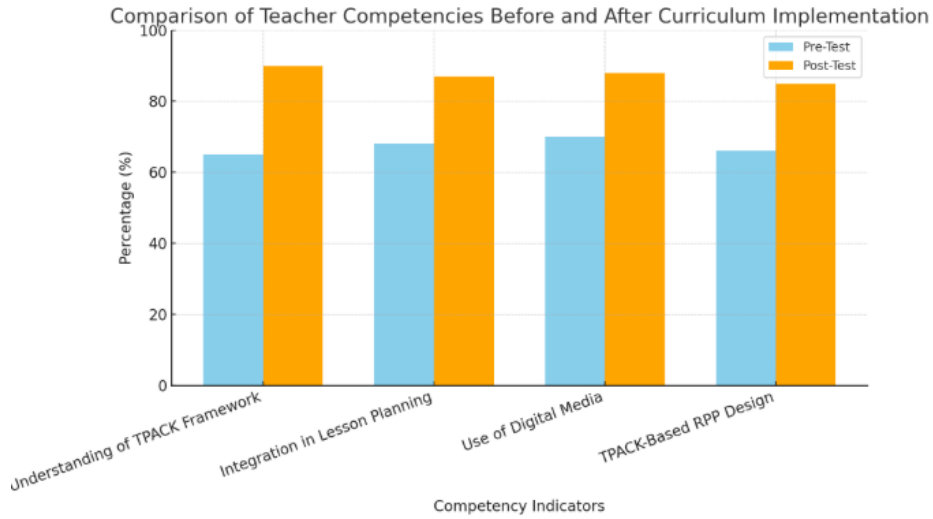

Figure 1. Pre-test and Post-test

Figure Description:

The bar chart illustrates the comparison of teacher competencies before (Pre-Test) and after (Post-Test) the implementation of the TPACK-based digital learning curriculum. Four key competency indicators are assessed: (1) understanding of the TPACK framework, (2) ability to integrate technology in lesson planning, (3) use of digital media in teaching, and (4) design of lesson plans (RPP) based on TPACK.

The chart shows a significant improvement across all indicators. The understanding of the TPACK framework increased from 65% to 90%, indicating a notable enhancement in conceptual knowledge. The ability to integrate technology in lesson planning rose from 68% to 87%, while the use of digital media improved from 70% to 88%. Similarly, the ability to design RPPs based on TPACK grew from 66% to 85%. These results suggest that the developed curriculum was effective in improving teachers' competencies in integrating technology, pedagogy, and content knowledge.

Overall, the chart confirms the positive impact of the curriculum intervention and supports the conclusion that TPACK-based curriculum development can enhance digital pedagogical practices among primary school teachers.

4. CONCLUSION

This study has successfully developed a TPACK-based digital learning curriculum tailored for primary school teachers, aiming to enhance their competencies in integrating technology into pedagogical and content knowledge. Through a structured Research and Development (R&D) approach using the ADDIE model, the curriculum was designed, validated, and implemented in a real classroom context.

The results showed that the curriculum met the criteria of being highly feasible, as confirmed by expert validation. Furthermore, limited trials demonstrated that the curriculum effectively improved teachers' ability to plan and deliver digital-based lessons in line with the TPACK framework. Quantitative data revealed a significant increase in teacher competencies across key indicators such as technological understanding, lesson planning, and instructional design. Qualitative findings also indicated a positive shift in teacher confidence and student engagement.

In conclusion, the TPACK-based curriculum offers a practical and impactful solution for preparing primary school teachers to face the challenges of 21st-century education. It bridges the gap between theory and practice by equipping teachers with a structured framework for implementing meaningful digital pedagogy. This research contributes to the ongoing discourse on curriculum innovation and highlights the importance of integrating technological knowledge into teacher professional development. Future efforts should focus on scaling the curriculum across broader educational settings and incorporating ongoing support systems to sustain teacher growth in digital competence.

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