The Development of Interactive Multimedia Based on Technological Pedagogical Content Knowledge (TPACK) to Improve the Learning Outcomes of 5th Grade Elementary School Students

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Abstract: This study aims to develop interactive multimedia based on Technological Pedagogical Content Knowledge (TPACK) to improve fifth-grade elementary students' learning outcomes. The research was motivated by students' low learning interest, limited use of engaging learning media, and insufficient tools to support material comprehension. This research used a Research and Development (R&D) approach with the 4D model, consisting of the stages of Define, Design, Develop, and Disseminate (limited to the development stage). The multimedia's validity was evaluated by material, media, and language experts; practicality was measured through teacher and student response questionnaires; and effectiveness was analyzed using pretest–posttest data with a t-test. The findings indicate that the developed multimedia met the validity, practicality, and effectiveness criteria, showing improvements in students' learning outcomes. The developed TPACK-based multimedia proved suitable for use in Pancasila Education for grade V elementary school. The study implies that the multimedia can enhance student engagement, promote independent learning, and strengthen understanding of Pancasila values within Indonesia's cultural diversity. However, the study was limited to the development phase and has not yet undergone large-scale dissemination.

Keywords: Elementry school; Interactive multimedia; Learning outcomes; TPACK

Introduction

The rapid development of Information and Communication Technology (ICT) has had a significant impact on the transformation of the world of education. The use of technology is now an integral part of the learning process because it can help teachers design innovative learning media and facilitate students in understanding concepts more effectively (Setiawan et al., 2023; Permana et al., 2024; Nurkamilah et al., 2020). The appropriate use of technology can improve the quality of learning, expand access to information, and prepare students to face the challenges and competencies of the 21st century (Dewi, 2024; Khasanah, 2024; Sari & Munir, 2024).

One form of integrating ICT in learning activities is the development of interactive multimedia, which is media that combines text, image, audio, animation, and video elements to create an engaging, contextual, and meaningful learning experience (Anggara & Supardji, 2024; Firdaus & Prasetyo, 2025; Hossain, 2023; Yusuf et al., 2024). The use of interactive multimedia has been

proven to be able to encourage active student involvement and shift learning patterns from teacher-centered to student-centered. Therefore, teachers are required not only to master technology, but also to have pedagogical skills and creativity in integrating the media effectively (Désiron et al., 2025; Dogan et al., 2021; Hidayat et al., 2024).

One of the relevant approaches to realize such integration is Technological Pedagogical Content Knowledge (TPACK). This model emphasizes the importance of a balance between technological mastery, pedagogy, and learning content (Ismail et al., 2023; Li et al., 2022; Shabira et al., 2024). Through TPACK, teachers can adjust the use of technology to the characteristics of students, teaching materials, and learning objectives (Wulandari, 2019). This approach is very relevant applied to subjects that require an understanding of values and social contexts, such as Pancasila Education (Aeni et al., 2024; Pinem et al., 2025; Widjajanti et al., 2021).

In the context of national education, Pancasila Education has a strategic role in shaping the character, morals, and national identity of students (Aggi Nurhapipah, 2024; Aprilia et al., 2022; Lestari & Kurnia, 2022; Nur et al., 2023). However, the results of initial observations at SD Negeri 18 Balai Satu show that Pancasila learning is still taking place conventionally, where teachers are more dominant using lecture methods with limited media use. This condition has an impact on low student participation and not optimal learning outcomes, which is shown by student achievements that are still below the Minimum Completeness Criteria (KKM).

Based on these conditions, learning innovations are needed that are able to combine the TPACK approach with the development of interactive multimedia in the context of Pancasila Education. This innovation is expected to improve the quality of the learning process and outcomes, foster student motivation, and strengthen the internalization of Pancasila values in a more interesting and meaningful way. The novelty of this research lies in the application of the TPACK model in the development of interactive multimedia for learning Pancasila Education in elementary schools, which until now has been rarely researched. Thus, the results of this research are expected to contribute to strengthening character education through effective and contextual technology integration.

Method

This research uses a research and development method with a 4D development model consisting of four stages, namely Define, Design, Develop, and Disseminate (Indaryanti et al., 2025; Syam & Furwana,

2022). At the Define stage, a series of analyses were carried out including curriculum analysis, student characteristics, task analysis, concept analysis, and learning objective analysis (Irawan et al., 2018; Pilendia & Amalia, 2020). This analysis aims to identify the needs and determine the direction of TPACK-based interactive multimedia development that is in accordance with student characteristics and learning objectives.

The Design stage involves the preparation of the initial design of the learning media, which includes the preparation of test instruments, the selection of formats and media (Hardika et al., 2024) and the creation of the initial design of multimedia using the Articulate Storyline application. Furthermore, at the develop stage, validation is carried out by experts to assess the validity (Hl et al., 2023; Nasution, et al., 2022) of the multimedia developed. After obtaining adequate validation results, a limited trial was carried out on teachers and students to assess the practicality and effectiveness aspects of the learning media produced.

The final stage, namely Disseminate, is carried out after multimedia is declared valid, practical, and effective. At this stage, the media is disseminated to be used more widely by teachers and students (Arwini et al., 2025). The subject of the study is a grade V student of SDN 18 Balai Satu. The research instruments used include interviews, questionnaires, observations, documentation, tests, as well as validation and practicality sheets.

Data analysis was carried out quantitatively and qualitatively. Media validity testing is carried out with the formula:

$$Validity\ value = \frac{obtained\ score}{maxsimum\ score}\ x\ 100\% \qquad (1)$$

Meanwhile, the practicality test is calculated using the formula:

$$The\ value\ of\ practicality = \frac{Skor\ generation}{Maximum\ score}\ x\ 100\% \qquad (2)$$

The effectiveness test was carried out using the Likert scale and the t-test to see the difference between pre-test and post-test results, with the formula:
d = pre test score –post tes score
Calculating the mean difference

$$Md = \frac{\Sigma d}{N} \qquad (3)$$

Calculate using the formula t

$$t = \frac{Md}{\sqrt{\frac{\Sigma x2d}{N(N-1)}}} \qquad (4)$$

The results of this analysis were used to determine the level of validity, practicality, and effectiveness of the TPACK-based interactive multimedia developed in this study.

Result and Discussion

Define Stage

The define stage produces four main analyses, namely the analysis of needs, characteristics of students, curriculum, and material concepts. Based on the results of observations and interviews in grade V of SDN 18 Balai Satu, it was found that Pancasila Education learning is still conventional with the dominance of lecture methods and the use of textbooks without interactive multimedia support. This has an impact on the low interest in learning of students and learning outcomes that have not reached the KKM. Based on Piaget's theory of development, students at the concrete operational stage are more likely to understand material through visualization and direct interaction. Therefore, interesting, contextual, and technology-based learning media is needed. The Merdeka Curriculum provides flexibility for teachers to integrate technology, with learning outcomes that emphasize the value of unity and diversity of Indonesian culture. The material developed is focused on the theme "Indonesian Cultural Diversity" to foster an attitude of appreciation and preservation of the nation's culture.

Design Stage

At this stage, research instruments are prepared to support the validation and evaluation of the developed interactive multimedia products. These instruments include expert validation sheets (materials, media, and language), student response questionnaires, student activity observation sheets, and learning outcome tests. The media is designed using the TPACK approach that integrates Pancasila Education content, active pedagogical strategies, and technology through the Articulate Storyline application. The initial design includes the preparation of storyboards, the formulation of learning objectives according to the Independent Curriculum, as well as the creation of visual displays, animations, videos, and interactive quiz features to increase students' active involvement in learning.

Development Stage

At the development stage, the process of making initial products, expert validation, revisions, and limited trials is carried out. Validation was carried out by three experts (material, media, and language) with an average result of 86.06% which is included in the very valid category. These results show that the developed media has met the criteria of content feasibility, design

suitability, and language clarity. These findings are in line with research conducted by (Subagja et al., 2023), which reported that the results of TPACK-based interactive multimedia validation obtained a score of 98% from subject matter experts and 99.4% from media experts, both in the very valid category. These results show that the developed product is feasible to use in terms of content, display, and language, and strengthens the evidence that expert validation is an important indicator of the level of practicality and feasibility of learning media to be implemented in the classroom.

Figure 1. Cover display

Figure 2. Page views

Figure 3. Menu home

Figure 4. Material section

Figure 5. Games display

The practicality of the media was tested through three stages of individual, small group, and limited large group trials with average results of 82.85%, 83.56%, and 85.00% respectively (the very practical category). In addition, the teacher's assessment of the practicality of the media reached 90.83% (very practical), which shows that the media is easy to use, time-efficient, and in accordance with the characteristics of the students.

The effectiveness of interactive multimedia was tested through a comparison of students' pretest and posttest results using a t-test. The results of the analysis showed that the value of t-calculation = 19.98 > t-table = 2.131 at a significance level of 5%, so that there was a significant difference between learning outcomes before and after the use of media. This proves that TPACK-based interactive multimedia is effective in improving student learning outcomes.

Disseminate Stage

The dissemination stage has not yet been carried out in this study and is recommended as a follow-up for subsequent research.

Discussion

The results of validation, practicality, and effectiveness show that TPACK-based interactive

multimedia development meets the eligibility criteria. High validity indicates the suitability of the content with the curriculum as well as the alignment between aspects of technology, pedagogy, and content. An excellent level of practicality signifies that the media is easy for teachers to use and appealing to students, in line with TPACK's theory that emphasizes a balance between mastery of technology, pedagogy, and learning content. Significant effectiveness shows that the use of interactive multimedia is able to increase the understanding of Pancasila values, especially in the context of Indonesia's cultural diversity.

Conclusion

This study developed TPACK-based interactive multimedia for Pancasila Education learning on the theme Cultural Diversity of Indonesia for fifth-grade elementary students using the 4D development model (Define, Design, Develop, and Disseminate). The results indicated that the developed multimedia achieved a very high validity level of 86.06%, demonstrating the alignment between content, pedagogy, and technology. The practicality test obtained an average score of 85.56%, categorized as very practical, implying that the media is easy to use, time-efficient, and engaging for both teachers and students. The effectiveness test using a paired t-test showed a significant improvement in learning outcomes with t-count = 19.98 > t-table = 2.131 at a 5% significance level. Therefore, the TPACK-based interactive multimedia developed in this study is proven to be valid, practical, and effective in improving students' learning outcomes in Pancasila Education. The findings imply that integrating technological, pedagogical, and content knowledge can enhance students' understanding of Pancasila values and promote meaningful, engaging learning experiences. Future research is recommended to conduct the dissemination stage to expand the use of this multimedia across various elementary education contexts.

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Conceptualization, W and R.; methodology, W.; software, W.; validation, W, R, A, and R.; Formal analysis, W.; Research, W.; resources, W; data curation, W.; writing—preparation of original drafts, W.; writing—review and editing, W and R;. All

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