United International Journal for Research & Technology
Volume 07, Issue 10, 2026 | Open Access | ISSN: 2582-6832

The Effect of TPACK-Based Interactive Learning Media on Students' Critical Thinking Skills in Elementary School Science and Social Studies Learning

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***Abstract*—** Developing students' critical thinking skills is one of the primary objectives of Science and Social Studies learning in elementary schools. However, achieving this objective remains challenging because classroom instruction has not fully utilized learning media that actively engage students in the learning process. This study aimed to examine the effect of TPACK-based interactive learning media on elementary school students' critical thinking skills. This research employed a quantitative approach using a quasi-experimental method with a pretest–posttest control group design. The sample consisted of 62 students, including 32 students in the experimental group and 30 students in the control group, selected through purposive sampling. Data were collected using a critical thinking skills test and analyzed using normality and homogeneity tests, an independent samples t-test, and the normalized gain (N-Gain) test. The findings revealed a statistically significant difference between the experimental and control groups ($p < 0.01$). Furthermore, the experimental group demonstrated a higher improvement in critical thinking skills, with an average N-Gain score of 0.303 (moderate category), whereas the control group achieved an average N-Gain score of 0.102 (low category). These findings indicate that TPACK-based interactive learning media have a positive effect on improving elementary school students' critical thinking skills.

***Keywords*—** Critical thinking skills, Elementary education, Interactive learning media, TPACK.

I. INTRODUCTION

Critical thinking skills are among the essential competencies that students need to develop to meet the challenges of twenty-first-century learning. These skills involve not only understanding information but also analyzing problems, evaluating the accuracy of information, constructing evidence-based arguments, and making rational decisions. As part of Higher Order Thinking Skills (HOTS), critical thinking needs to be developed from the elementary school level to enable students to respond to various situations and problems logically and reflectively, as emphasized by O'Reilly et al. [1]. Therefore, learning should be designed to provide students with opportunities to think actively, explore knowledge, and construct their understanding through meaningful learning experiences.

One subject area with considerable potential for developing these skills is Science and Social Studies learning, known as Ilmu Pengetahuan Alam dan Sosial (IPAS) in the Indonesian elementary education curriculum. According to the Indonesian Ministry of Education, Culture, Research, and Technology (Kemendikbud) [2], IPAS integrates concepts from natural and social sciences to help students understand phenomena in their surrounding environment through activities such as observing, questioning, investigating, processing information, and drawing conclusions based on evidence. These characteristics make IPAS learning relevant to the development of critical thinking skills because students are encouraged to connect the concepts they learn with real-life problems and phenomena.

However, the implementation of IPAS learning in elementary schools still faces various challenges. Learning activities tend to remain teacher-centered, while the use of learning media is often limited and less varied, resulting in insufficient opportunities for students to actively participate in the learning process. Consequently, students tend to receive information rather than process and develop it through higher-

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order thinking activities. As a result, their abilities to analyze problems, provide logical reasoning, and draw evidence-based conclusions remain relatively low, as reported by Rahmawati et al. [3]. Similarly, Rahayu and Laili [4] reported that elementary school students' critical thinking skills were still at a low level. This finding is further supported by Eka Wahyudi et al. [5], who found that most students had not demonstrated critical thinking skills optimally, with only a small proportion reaching the high category.

A similar problem was identified at SD Negeri 1 Wonoharjo. Based on the researchers' preliminary observations, approximately 65% of fifth-grade students experienced difficulties when working on questions requiring critical thinking skills, particularly in analyzing problems, providing evidence-based reasoning, and relating IPAS concepts to phenomena encountered in everyday life. These findings indicate that the objective of IPAS learning to develop students' critical thinking skills has not yet been fully achieved. One factor that may contribute to this condition is the use of learning media that has not sufficiently encouraged students' active engagement throughout the learning process.

One potential approach to addressing this problem is the use of interactive learning media developed based on the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK emphasizes the integration of content knowledge, pedagogical knowledge, and technological knowledge, enabling teachers to design learning that corresponds to students' characteristics while utilizing technology effectively, as explained by Mishra and Koehler [6]. In the context of IPAS learning, TPACK-based interactive media can provide students with more engaging learning experiences through the visual, interactive, and contextual presentation of learning materials. Consequently, students are not merely exposed to information but are encouraged to observe, explore, analyze, and solve problems related to their surrounding environment, as supported by Koehler et al. [7].

Several previous studies have demonstrated that the application of TPACK can contribute positively to the improvement of learning quality and students' critical thinking skills. Handini [8] explained that teachers' TPACK knowledge enables them to integrate technology appropriately with the characteristics of learning content and instructional strategies, resulting in more effective and innovative learning processes and increased student participation. Adelia and Satianingsih [9] also found that learning based on the TPACK framework had a positive effect on students' critical thinking skills. Similarly, Hikmah and Radiansyah [10] reported that TPACK integration in learning could increase student learning activities while supporting the development of critical thinking skills.

Nevertheless, most previous studies have combined the TPACK framework with particular learning models, particularly Problem-Based Learning (PBL). Research specifically examining the effect of TPACK-based interactive learning media as the main instructional variable on students' critical thinking skills in elementary school Science and Social Studies learning remains relatively limited. This gap indicates the need for further empirical investigation into the direct contribution of TPACK-based interactive learning media to students' critical thinking development. Therefore, this study aims to examine the effect of TPACK-based interactive learning media on the critical thinking skills of fifth-grade elementary school students in Science and Social Studies learning at SD Negeri 1 Wonoharjo.

II. METHOD

This study employed a quantitative approach using a quasi-experimental method with a pretest–posttest control group design. The study was conducted during the even semester of the 2025/2026 academic year at SD Negeri 1 Wonoharjo, Kemusu District, Boyolali Regency. The experimental group received IPAS instruction using interactive learning media based on Technological Pedagogical Content Knowledge (TPACK), while the control group received instruction using the learning media commonly used by the teacher.

The participants were fifth-grade students with a total sample of 62 students selected through purposive

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sampling. The sample consisted of 32 students in the experimental group and 30 students in the control group. The selection of the two groups considered the similarity of grade level, learning materials, and curriculum to ensure relatively comparable characteristics between the groups.

Data were collected using a critical thinking skills test consisting of 10 essay items developed based on the critical thinking indicators proposed by Ennis. The test was administered twice, namely before the treatment (pretest) to measure students' initial critical thinking skills and after the treatment (posttest) to determine changes in students' critical thinking skills following the learning process. Observation and documentation were also employed as supporting data to obtain information regarding the implementation of the learning process during the study.

Before being administered, the test instrument was examined for validity and reliability to ensure its suitability as a research instrument. The collected data were analyzed using IBM SPSS Statistics version 30. The analysis began with the Shapiro–Wilk normality test to determine whether the data were normally distributed, followed by Levene's Test to examine the homogeneity of variances between the experimental and control groups.

After the assumptions were met, an Independent Samples t-test was conducted at a 5% significance level to examine the effect of TPACK-based interactive learning media on students' critical thinking skills.

In addition, the Normalized Gain (N-Gain) test was used to determine the magnitude of improvement in students' critical thinking skills in each group and to evaluate the effectiveness of the intervention.

III. RESULT AND DISCUSSION

Students' Critical Thinking Skills Before and After the Intervention

Students' critical thinking skills were analyzed based on the pretest and posttest results obtained from the experimental and control groups. Descriptive analysis was conducted to identify students' initial critical thinking skills and the changes that occurred following the learning intervention. The results are presented in Table 1.

Table 1. *Mean Pretest, Posttest, and N-Gain Scores*

Group	Pretest	Posttest	N-Gain
Experimental	57,97	70,86	0,303
Control	57,08	60,83	0,102

The results show that the initial critical thinking skills of the two groups were relatively comparable. The experimental group obtained a mean pretest score of 57.97, while the control group obtained 57.08. The relatively small difference between the two groups indicates that their initial conditions were relatively similar before the intervention.

After the learning process, both groups demonstrated an increase in critical thinking scores, although the magnitude of improvement differed considerably. The mean posttest score of the experimental group increased to 70.86, whereas the control group reached 60.83. Thus, the experimental group experienced an increase of 12.89 points, while the control group increased by only 3.75 points.

The greater improvement observed in the experimental group suggests that the use of TPACK-based interactive learning media provided a more supportive learning environment for developing students' critical thinking skills. The interactive presentation of learning materials enabled students to engage with IPAS concepts through visual representations, learning activities, and contextual information rather than relying solely on teacher explanations.

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The Effect of TPACK-Based Interactive Learning Media on Critical Thinking Skills

The difference in students' critical thinking skills between the experimental and control groups was further examined through inferential statistical analysis. Before hypothesis testing, the data were examined for normality and homogeneity. The results of the Shapiro–Wilk test indicated that the data were normally distributed, while Levene's Test showed that the variances of the two groups were homogeneous. Therefore, the data met the assumptions for conducting an Independent Samples t-test.

The Independent Samples t-test produced a significance value of less than 0.01. This result indicates a statistically significant difference in critical thinking skills between the experimental and control groups after the learning intervention. Therefore, the null hypothesis was rejected, indicating that the use of TPACK-based interactive learning media had a significant effect on the critical thinking skills of fifth-grade students in IPAS learning.

The finding indicates that the improvement in the experimental group was not merely associated with differences in students' initial abilities. Instead, the learning intervention using TPACK-based interactive media contributed to the differences observed between the two groups. The integration of technology, pedagogy, and content allowed learning materials to be presented in ways that were more aligned with students' learning characteristics and the nature of IPAS content.

This finding is consistent with the TPACK framework proposed by Mishra and Koehler [6], which emphasizes that effective technology integration requires the interaction of technological knowledge, pedagogical knowledge, and content knowledge. In this study, technology was not used merely as an additional tool for presenting information. Rather, it was integrated with instructional strategies and IPAS content to facilitate students' active engagement in the learning process.

Improvement of Critical Thinking Skills Based on N-Gain

The effectiveness of the learning intervention in improving students' critical thinking skills was further examined using the Normalized Gain (N-Gain). The experimental group obtained a mean N-Gain score of 0.303, which was categorized as moderate, while the control group obtained a mean N-Gain score of 0.102, which was categorized as low.

The difference in N-Gain scores indicates that students who participated in learning using TPACK-based interactive media experienced greater improvement in critical thinking skills than students who participated in learning using the media commonly employed by the teacher. The comparison is illustrated in Figure 1.

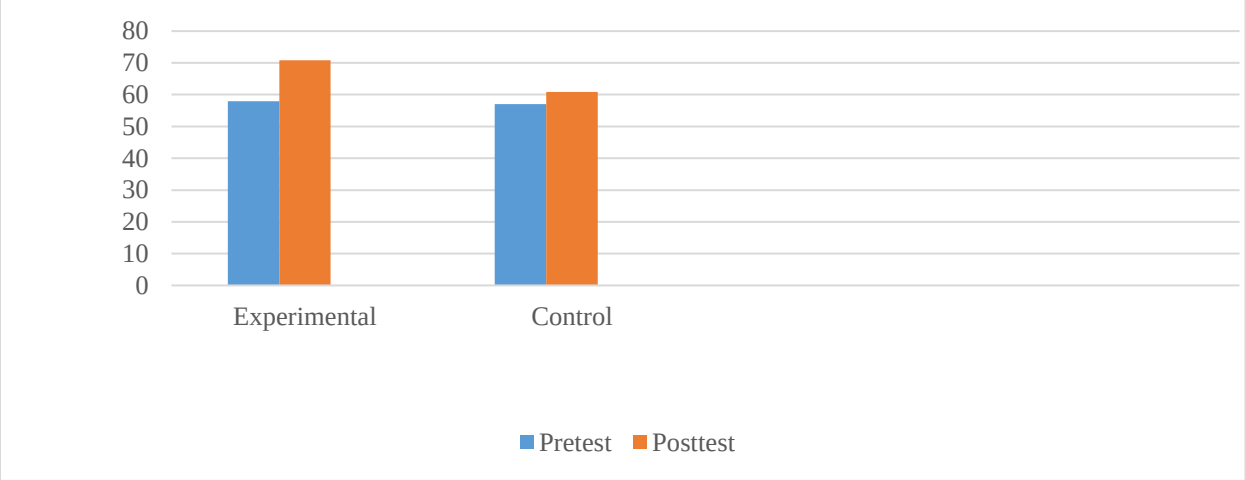

Figure 1. *Improvement in Students' Critical Thinking Skills*

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The moderate N-Gain achieved by the experimental group indicates that the intervention contributed positively to the development of students' critical thinking skills, although the improvement had not yet reached the high category. This finding is important because critical thinking is a complex skill that cannot generally be developed through a single learning intervention. Continuous opportunities to analyze information, evaluate evidence, formulate arguments, and draw conclusions are needed to strengthen these skills.

The improvement observed in the experimental group can be explained by the characteristics of the interactive learning media used in the learning process. The integration of images, videos, animations, and interactive activities provided students with opportunities to explore IPAS concepts more concretely. These activities encouraged students to identify problems, analyze relevant information, provide reasoning based on evidence, and formulate logical conclusions.

Contribution of TPACK-Based Interactive Media to Critical Thinking Development

The findings indicate that the contribution of TPACK-based interactive learning media extends beyond the use of technology itself. The effectiveness of the media lies in how technology is integrated with appropriate pedagogical strategies and relevant IPAS content. Through this integration, students were provided with opportunities to participate more actively in the learning process and construct their understanding through meaningful learning experiences.

The use of interactive media allowed learning materials to be presented visually and contextually, making abstract or complex IPAS concepts more accessible to elementary school students. At the same time, the pedagogical design of the learning activities encouraged students to observe, explore, analyze, and solve problems related to phenomena in their surrounding environment. These activities correspond to the processes involved in critical thinking development.

The finding is consistent with Handini and Mustofa [8], who reported that the implementation of the Technological Pedagogical Content Knowledge (TPACK) framework enables teachers to integrate technology, instructional strategies, and learning content in a balanced manner. Such integration can create more interactive learning environments, increase student participation, and provide more meaningful learning experiences.

The results also support the findings of Adelia and Satianingsih [9], who reported a positive effect of TPACK-based learning on students' critical thinking skills in IPAS learning. Similarly, Mulyani et al. [11] found that TPACK-based interactive multimedia could increase student engagement while strengthening conceptual understanding. Nisfah et al. [12] further explained that TPACK integration can support the development of Higher Order Thinking Skills (HOTS), including critical thinking, through learning activities involving investigation, analysis, and problem solving supported by technology.

Taken together, these findings suggest that the development of students' critical thinking skills does not occur simply because digital technology is introduced into the classroom. Rather, the improvement depends on how technology is integrated with appropriate pedagogy and meaningful content. In the present study, TPACK-based interactive learning media created opportunities for students to engage actively with IPAS materials, examine information, connect concepts with real-life phenomena, and formulate conclusions based on their understanding. Therefore, TPACK-based interactive learning media can be considered a potential instructional alternative for supporting the development of critical thinking skills in elementary school IPAS learning.

VI. CONCLUSION

This study demonstrates that the use of interactive learning media based on Technological Pedagogical Content Knowledge (TPACK) has a positive effect on the critical thinking skills of fifth-grade students in IPAS learning. This finding is supported by the results of the Independent Samples t-test, which indicated a significant difference in students' critical thinking

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skills between the experimental and control groups after the intervention. The effectiveness of the intervention was further supported by the Normalized Gain (N-Gain) analysis, in which the experimental group achieved a moderate level of improvement, whereas the control group demonstrated a low level of improvement. These findings indicate that the integration of technology, pedagogical strategies, and content knowledge through the TPACK framework can facilitate more interactive, contextual, and meaningful learning experiences, thereby supporting the development of elementary students' critical thinking skills.

Interactive learning media based on TPACK can be considered an alternative approach to improving the quality of IPAS learning, particularly in developing students' critical thinking skills. Teachers are encouraged to optimize the use of technology by ensuring alignment among learning content, pedagogical strategies, technological tools, and students' characteristics so that TPACK can be implemented effectively. Future researchers are encouraged to conduct studies involving larger samples and longer intervention periods, as well as to investigate the application of TPACK-based interactive media to other learning outcomes, such as creativity, problem-solving skills, collaboration, and learning motivation. Such studies may provide a more comprehensive understanding of the effectiveness and broader potential of TPACK-based interactive learning media in elementary education.

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