

THE EFFECT OF DIGITAL INTERACTIVE BOARD MEDIA ON CRITICAL THINKING SKILLS OF SIXTH GRADE ELEMENTARY SCHOOL STUDENTS

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ABSTRACT

This study was conducted to examine the effectiveness of using a Digital Interactive Board (DIB) to improve the critical thinking skills of sixth-grade elementary school students. Critical thinking skills are an essential element of 21st-century knowledge that must be instilled from the elementary education level. The method used in this research was a quasi-experimental design with a nonequivalent control group design. The sample of this study was divided into two groups, where the control group consisted of 20 students using conventional methods and the experimental group consisted of 20 students assisted by the DIB. Interpretation, analysis, evaluation, and inference were the four critical thinking indicators used for data collection in the form of essay tests. To analyze the data, this study used an independent t-test and N-Gain calculation. The research findings revealed that the posttest results of the experimental group, which obtained an average score of 81.50, were significantly superior to the control group, which obtained 57.75. This difference was statistically significant ($p = 0.000 < 0.05$) with a Cohen's d effect size of 1.84, falling into the very large category. The control group, which obtained an N-Gain of 0.21 (low category), was far exceeded by the experimental group's N-Gain value, which reached 0.64 (medium category). The most prominent improvement was recorded in the analysis indicator with an N-Gain value of 0.71 and the evaluation indicator at 0.70. The researcher concluded that the Digital Interactive Board has proven effective in improving elementary school students' critical thinking skills, particularly in the aspects of analysis and evaluation. Therefore, it is recommended that schools integrate continuous pedagogical training to optimize the use of multi-touch features and dynamic visualization in the learning process.

Informasi Artikel

Kata Kunci:

Berpikir kritis, kuasi eksperimen, media interaktif, papan interaktif digital, sekolah dasar.

ABSTRAK

Dilakukannya studi ini untuk mengkaji efektivitas penggunaan Papan Interaktif Digital (PID) guna meningkatkan daya pikir kritis siswa sekolah dasar di kelas VI. Kecakapan berpikir kritis menjadi salah satu unsur penting pada pengetahuan abad kedua satu yang harus ditanamkan sejak tingkat pendidikan dasar. Metode apa yang digunakan dalam penelitian ini yaitu desain kuasi-eksperimen dengan tipe nonequivalent control grup desain. Sampel studi ini terbagi dua kelompok, dimana kelompok kontrol 20 siswa dengan metode konvensional dan kelompok eksperimen 20 siswa dengan berbantu PID. Interpretasi, analisis, evaluasi dan inferensi menjadi empat indikator daya pikir kritis yang digunakan dalam pengumpulan data dalam bentuk tes uraian. Untuk menganalisis data, studi ini menggunakan teknik uji-t independen dan perhitungan N-Gain. Hasil posttest menunjukkan bahwa kelompok eksperimen memperoleh nilai rata-rata sebesar 81,50 terbukti lebih unggul secara signifikan dibandingkan kelompok kontrol yang memperoleh 57,75, yang secara statistik terbukti signifikan ($p = 0,000 < 0,05$) serta besar efek Cohen's $d = 1,84$ yang masuk kategori sangat besar, diungkapkan oleh temuan penelitian. Kelompok kontrol yang memperoleh N-Gain sebesar 0,21 (kategori rendah) dilampaui jauh oleh nilai N-Gain kelompok eksperimen yang mencapai angka 0,64 (kategori sedang). Peningkatan paling menonjol tercatat pada indikator analisis dimana nilai N-Gain 0,71 serta nilai evaluasi 0,70. Peneliti menarik kesimpulan bahwa Papan Interaktif Digital terbukti mampu meningkatkan kemampuan daya pikir kritis siswa SD secara efektif, pada aspek analisis serta evaluasi. Oleh karena itu, sekolah disarankan untuk mengintegrasikan pelatihan pedagogis secara berkesinambungan guna mengoptimalkan pemanfaatan fitur multi-touch dan visualisasi dinamis dalam proses pembelajaran.

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1. Introduction

Fundamental changes in the world of education began with the advent of the digital age, particularly at the elementary school level, which serves as the foundation for building students' competencies [1]. In sixth grade, students are in a transitional phase from concrete thinking to formal operational thinking, enabling them to engage in more abstract reasoning and analyze the information they receive. However, in practice, it has been found that in Indonesia, the level of critical thinking skills among elementary school students is relatively low. One study noted that the improvement in critical thinking skills following an intervention reached an N-Gain value of 0.61 [2]. Even more concerning is that almost no Indonesian students have managed to exceed Level 4 on international critical thinking assessment standards. This situation further underscores the need for empirical research to examine the extent to which state-of-the-art interactive media, such as Digital Interactive Whiteboards, can foster the development of higher-order thinking skills among elementary school students. Within the framework of 21st-century competencies, critical thinking skills occupy a central position alongside creativity, collaboration, and communication, as well as literacy and numeracy skills [3]. One of the key components of the Graduate Profile in the Merdeka Curriculum is critical thinking, which must be developed starting in elementary school. Self-regulation, interpretation, analysis, evaluation, inference, and explanation are the main characteristics of critical thinking. Critical thinking involves a purposeful and goal-oriented mental process [4]. According to research, the use of interactive digital media can enhance creativity (N-Gain 0.80), evaluation (N-Gain 0.75), and problem-solving (N-Gain 0.79). [5], [6]. Without adequate visual and interactive stimulation, students often face difficulties in constructing arguments and analyzing complex information [7]. This low level of critical thinking ability is also reflected in various studies that have found that the majority of students still struggle to analyze and evaluate information [8]. In response to this issue, a number of researchers have developed interactive media to improve critical thinking skills, which have also been shown to contribute to science education—one example being the “Si Jagad” media [9].

In progressive schools, technological innovations have begun to incorporate digital interactive whiteboards—high-resolution touchscreen devices with digital collaboration features, internet connectivity, and real-time annotation capabilities [10]. Digital interactive whiteboards offer a higher level of interactivity compared to conventional whiteboards because they allow more than one user to participate simultaneously, thereby enhancing students' behavioral and cognitive engagement [11]. Students can more easily understand complex scientific phenomena by visualizing them. In the context of science education, digital interactive whiteboards offer pedagogical solutions that far exceed the functions of ordinary projectors [12]. Previous systematic reviews have shown that problem-based learning models combined with interactive media have the potential to enhance critical thinking skills, resulting in high N-Gain scores [13]. Furthermore, multimedia-based interactive media that meet validity and effectiveness standards have also been shown to improve learning outcomes while

honoring students' critical thinking skills [14]. One study indicates that while interactive media are useful, their impact on each metric of critical thinking varies and requires further research [15].

Learning using digital interactive whiteboards and conventional learning differ significantly in several key aspects that help students develop critical thinking skills [16]. Digital interactive whiteboards provide students with instant access to simulations, dynamic multimedia, and databases. In contrast, conventional learning relies on printed materials and one-way information transfer. Digital interactive whiteboards offer real-time access to digital simulations, web content, and interactive multimedia. On the other hand, conventional learning relies on textbooks and the teacher's verbal explanations. Digital interactive whiteboards enable immediate feedback through interactive quizzes and collaborative annotations. In contrast, conventional media—which is static and two-dimensional—offers dynamic feedback that students can manipulate directly with 4K resolution. Feedback in conventional learning tends to be delayed because students must wait for the teacher's evaluation, whereas Digital Interactive Whiteboards enable immediate feedback.

While student collaboration on conventional media is limited to verbal discussions, Digital Interactive Whiteboards support simultaneous participation through multi-touch, allowing multiple students to collaborate on a single screen [17]. Digital Interactive Whiteboards promote inquiry-based and problem-solving learning. In contrast, conventional teaching methods rely on rote learning [18]. Another study examined an interactive problem-based learning (PBL) module, showing that simultaneous interaction accelerates students' elaboration and evaluation. These communal participants align with the findings of this study [19]. At each stage of the experiment, research developing an interactive Canva-assisted PBL model found that interactive media enhances critical thinking skills effectively [20]. Previous researchers conducted a study indicating that the development of effective PBL-based interactive worksheets (N-Gain 0.69) improved elementary school students' critical thinking skills [21]. Software applications such as Canva-assisted modules, digital interactive books, and Articulate Storyline media were the focus of previous research [22]. Additional studies examined the use of Macromedia Flash and online quiz applications [23]. Furthermore, it was found that PBL-based Torma Code interactive media was able to improve elementary school students' critical thinking skills in the IPAS subject with moderate effectiveness and an N-Gain of 0.55 [24].

Digital Interactive Whiteboards have enormous potential, but there are still many issues hindering their implementation in Indonesia. A systematic literature review published in a Sinta 3-indexed journal found that the two main obstacles preventing the effective use of interactive technology are a lack of access to technology and teacher readiness [25]. Furthermore, although the PBL model supported by Canva interactive media has been extensively studied in relation to enhancing critical thinking, no study has specifically examined Digital Interactive Whiteboards with their multi-touch capabilities and 4K resolution [26]. Similarly, research on the development of

PBL-based interactive e-modules for fourth-grade elementary school students did not comprehensively assess all six of Facione's critical thinking indicators. Conversely, studies involving the development of digital modules based on Articulate Storyline have been less extensively studied compared to the use of direct interventions with Digital Interactive Whiteboards [27]. There are no experimental studies that specifically investigate the effect of Digital Interactive Whiteboards on Facione's six indicators of critical thinking in elementary schools in Indonesia. Other researchers have developed interactive media based on digital books, but neither of these studies tested Digital Interactive Whiteboards as specialized software with a communal touchscreen. Based on this background, this study was designed to examine how the use of Digital Interactive Whiteboards in sixth-grade elementary school classrooms affects students' critical thinking skills. The focus of this study stems from a gap in the existing literature: while various types of interactive media have indeed been proven effective, research on Digital Interactive Whiteboards—as devices with their own unique characteristics—remains very limited.

2. Method

This study employed a quantitative methodology with a quasi-experimental design, specifically the Nonequivalent Control Group Design [25]. This design was chosen because the study could alter the existing classroom structure at the school. In this study, participants were divided into two groups: the experimental group, which received instruction using a Digital Interactive Whiteboard, and the control group, which continued with conventional learning using a chalkboard and printed reading materials. Before the learning activities began, both groups took a pretest to assess their initial skills. After all stages of the learning process were completed, both groups took a posttest to measure their final achievements. The research was conducted at SDN 4 Sukajawa, involving 40 sixth-grade students as the research sample, consisting of 20 students from Class VI A in the experimental group and 20 students from Class VI B in the control group. The sample was selected using purposive sampling, taking into account that both classes were taught by the same teacher and had relatively equivalent average initial academic scores, so that the initial conditions of the two groups could be considered comparable. The data collection instrument consisted of a written test in the form of essay questions designed to measure students' critical thinking skills. These indicators measured four aspects—interpretation, analysis, evaluation, and inference—as formulated by Facione [4]. To ensure that the features of the Digital Interactive Whiteboard were actually used in the experimental class in accordance with the teaching module, brief observations were conducted during the learning process. Quantitative data analysis based on pretest and posttest scores was performed using the JASP statistical software. The data analysis process consisted of three stages. First, prerequisite tests were conducted, including a normality test using the Shapiro-Wilk test—selected because the sample size did not exceed 50 students—and a test of homogeneity of variances using Levene's test to verify the equality of variances between the two groups. Second, to determine whether there was a

significant difference in critical thinking skills between the experimental and control groups, an independent t-test was used. Third, the effectiveness was assessed by calculating the N-Gain value to measure the extent of growth in students' critical thinking skills after undergoing the learning process aided by the Digital Interactive Whiteboard.

3. Results and Discussion

To ensure that the parametric assumptions for hypothesis testing were met, the Shapiro-Wilk normality test and Levene's test of homogeneity were conducted. The results of the normality test showed that the pretest and posttest scores for both groups had significance values greater than 0.05, indicating that the data distribution was normal. However, the results of the test for homogeneity of variances showed that the variances of the two groups were equal, with a significance value of 0.184 [27].

The experimental group scored an average of 48.25, while the control group scored 46.50, with a difference of only 1.75 points on the pretest. This indicates that the initial abilities of the two groups were relatively balanced before the intervention was implemented. After the learning process was completed, the group that received instruction aided by the Digital Interactive Whiteboard recorded an average posttest score of 81.50, surpassing the control group, which scored 57.75. The results of the independent samples t-test yielded a calculated t-value of 8.421 with a significance level (two-tailed) of 0.000 ($p < 0.05$), leading to the rejection of the null hypothesis. This means there is a statistically significant difference in critical thinking ability between the two groups. The effect size was calculated using Cohen's d formula and yielded a value of 1.84, placing it in the very large effect size category ($d > 0.8$). These results demonstrate that the difference in posttest means is not only statistically significant but also has significant practical relevance for learning at the elementary school level. Similar results were also found in previous science studies, where the improvement in students' cognitive learning outcomes was more significant when using a Digital Interactive Whiteboard compared to conventional approaches. [26]

Based on the N-Gain score categorization, namely weak criteria ($g < 0.3$), moderate criteria ($0.3 \leq g \leq 0.7$), and strong criteria ($g > 0.7$) [27]. The experimental group achieved an N-Gain score of 0.64, falling into the moderate-to-high category, whereas the control group only reached 0.21, which is classified as low. This N-Gain gap—more than three times greater—clearly demonstrates that Digital Interactive Whiteboards are far more effective in promoting students' cognitive development than conventional media. Previous research findings indicate that problem-based learning supported by interactive media can strengthen elementary school students' conceptual understanding [8]. Thus, the Digital Interactive Whiteboard has been proven to serve not merely as a visual communication tool, but as a medium that actively trains students' critical thinking skills

Table 1. Pretest, Posttest and N-Gain Result

Group	Experimental (Digital Interactive Board)	Control
Average Pretest Score	48,25	46,50
Average Posttest Score	81,50	57,75
Average N-Gain Score	0,64	0,21
Category	Moderate	Weak

When analyzed by indicator, the most significant improvement in the experimental group occurred in the areas of analysis and evaluation. The average score for the analysis indicator jumped from 42.5 on the pretest to 79.3 on the posttest, resulting in an N-Gain of 0.71, which falls into the high category. Similarly, the evaluation indicator increased from 40.0 to 78.5, yielding an N-Gain of 0.70, also classified as high. The interpretation and inference indicators also showed increases in N-Gain, at 0.59 and 0.57, respectively. With the dynamic visualizations offered by the 4K Digital Interactive Whiteboard, students can observe abstract phenomena directly. This helps them identify arguments, find relationships between variables, and assess the credibility of information. The constantly changing visual representations in interactive media help students transition from the concrete operational stage to the formal stage [15].

It has been shown that the multi-touch feature of Digital Interactive Whiteboards can transform classroom dynamics from a teacher-centered approach to an active collaborative environment. During observations, three to four students can come to the front simultaneously to make annotations, analyze diagrams, and draw connecting lines between concepts in real time. Indicators of the ability to understand meaning and make inferences are directly developed through the process of negotiating meaning and peer correction carried out by students. Interactive touchscreen devices can enhance both behavioral and cognitive engagement while maintaining students' focus for longer periods [10]. In the experimental classroom, students can learn from teachers and classmates through intense academic interactions. In its systematic literature review, contrary to the positive findings of other studies, it was found that limited access to technology and teachers' skills often pose barriers to the use of interactive media in elementary schools [24]. In this study, this issue was addressed because teachers in the experimental group had undergone two weeks of intensive training prior to the

intervention. Thus, pedagogical factors did not act as confounding variables. However, this study has an important limitation: the non-equivalent control group design (pre-existing classes) meant that subjects were not selected randomly. Although pretest results indicated initial equivalence, threats to internal validity—such as history, maturation, or selection bias—could not be fully controlled. Furthermore, given that teachers and students were consciously observed during the learning process, the Hawthorne effect—behavioral changes caused by special attention—may also have played a role. The results indicate that the procurement of Digital Interactive Whiteboards in elementary schools should prioritize not only technical requirements but also be accompanied by ongoing pedagogical training for teachers. Schools should not simply use the projector feature as a substitute for a chalkboard. Instead, they must ensure that multi-touch features, collaborative annotation, and dynamic visualization are fully utilized in inquiry-based and problem-solving learning scenarios. Theoretically, this study demonstrates that Digital Interactive Whiteboards outperform conventional media in terms of analysis and evaluation indicators. This contributes to the body of research on instructional technology in elementary education.

4. Conclusion

Compared to conventional teaching approaches, the Digital Interactive Whiteboard significantly improved students' critical thinking skills. The conclusions drawn are based on the results of the analysis conducted. The experimental group recorded an average posttest score of 81.50, while the control group scored only 57.75. This difference is supported by a significance value of 0.000 ($p < 0.05$) and a Cohen's d effect size of 1.84, which is classified as very large. The effectiveness level of the Digital Interactive Whiteboard falls into the moderate-to-high category, as reflected by the average N-Gain score of 0.64, which is significantly higher than that of the control group, whose N-Gain was only 0.21. By indicator, the analysis aspect achieved an N-Gain score of 0.71 and the evaluation aspect scored 0.70, both of which fall into the high category. This demonstrates that the dynamic visualization features and multi-touch interactivity of the Digital Interactive Whiteboard function as effective cognitive scaffolding in helping students transition from concrete to formal thinking.

According to this study, schools and policymakers should utilize Digital Interactive Whiteboards as practical tools. They should also continue to provide teachers with digital education training. In this way, dynamic visualizations and multi-touch features can be incorporated into inquiry-based learning. For future researchers, it is recommended to extend the intervention period, include moderator variables such as learning styles and intrinsic motivation, and improve control over external factors. Theoretically, this study contributes to research on instructional technology in elementary education by demonstrating that Digital Interactive Whiteboards are capable of meeting the requirements for the analysis and evaluation of the Merdeka Curriculum.

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