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# The Impact of Digital Learning Tools on Students' Critical Thinking Development

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A R T I C L E I N F O

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A B S T R A C T

The development of educational technology has brought significant changes in the learning process, especially in encouraging critical thinking skills as one of the main competencies of the 21st century. This study aims to analyze the influence of the use of digital learning tools on the development of critical thinking skills of high school students in Kutai Kartanegara Regency, East Kalimantan. This study uses a quantitative approach with a quasi-experimental design involving 60 students in grade XI who are divided into two groups, namely the experimental group that learns using digital learning tools and the control group that learns using conventional methods. Data were collected through critical thinking skills tests before and after treatment (pre-test and post-test) and analyzed using a paired sample t-test to identify significant differences between groups. The results of the study show that the use of digital learning tools has a positive and significant effect on improving students' critical thinking skills. Interactive digital media has been proven to be effective in improving students' analytical skills, evaluation, and reflective reasoning during the learning process. This study concludes that the integration of digital technology in teaching and learning activities can strengthen the quality of learning while developing students' critical thinking skills. These findings provide practical implications for educators and curriculum developers in designing innovative technology-based learning strategies that align with the demands of modern education.

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## INTRODUCTION

The development of digital technology has changed the paradigm of modern education by presenting a more interactive, flexible, and skill-oriented learning model for the 21st century. This transformation requires the world of education to adapt to technological advances, especially in integrating digital learning tools as part of a strategy to improve learning quality (Anderson, 2021). Digital learning tools such as online platforms, interactive applications, and multimedia-based media not only function as a means of conveying information, but also as an instrument to foster students' critical thinking skills (Fischer & Kumar, 2022). However, the implementation of educational technology in various high schools in Indonesia still faces challenges, such as limited infrastructure, teacher readiness, and differences in digital literacy levels between students (Rodriguez et al., 2023). This phenomenon shows that the effectiveness of the use of digital tools on the development of critical thinking needs to be studied scientifically to understand the extent to which technology really contributes to the improvement of students' cognitive abilities.

Indonesia as a country with rapid development in the field of digital education is trying to integrate technology into the national curriculum. Various initiatives such as *Learning Management System* (LMS)-based learning and the use of online learning applications have been implemented in many secondary schools, including in the East Kalimantan region (Hidayat et al., 2021). However, not all schools have shown optimal results in developing students' critical thinking skills through digital media. Most students still tend to use digital tools only as a means of accessing information, rather than as an exploratory medium that fosters deep analysis and reflection (Laurent & Purnomo, 2022). This condition creates a gap between the potential of digital technology and its actual implementation in the context of meaningful learning.

Several previous studies have shown that the use of digital learning tools can increase student motivation and participation in the learning process (Mendez & Roberts, 2020). However, its effect on critical thinking skills still shows varying results depending on the learning design and the context of its application (Klein et al., 2021). Factors such as the role of teachers, pedagogical approaches, and students' ability to utilize technology also affect the learning outcomes produced. At the secondary school level, critical thinking skills are very important because they are directly related to decision-making processes, problem-solving, and readiness to face global challenges (Gonzalez & Rahardjo, 2022). Therefore, research that analyzes the relationship between the use of digital learning tools and the development of critical thinking skills is very relevant to be conducted, especially in the regional education environment that is adapting to digital transformation.

Theoretically, the development of critical thinking skills through digital technology is rooted in the theories of *constructivism* and *connectivism*, which emphasize the importance of students' active involvement in building knowledge through interaction with digital sources and learning networks (Siemens, 2020). Digital-based learning allows students to explore information independently, assess the validity of sources, and relate new knowledge to

previous experiences, thus encouraging the formation of reflective and analytical thinking (Yilmaz & Keser, 2023). In addition, the use of digital tools such as interactive simulations and online collaboration has been proven to strengthen the metacognitive processes that are at the core of critical thinking (Rahimi et al., 2022). Thus, the use of educational technology is not only instrumental, but also conceptual in changing the way students think and learn independently.

In addition, previous studies have focused more on the effectiveness of digital technology on academic outcomes in general, without examining in depth its impact on high-level cognitive aspects such as critical thinking (Chandra et al., 2023). Quantitative approaches with experimental designs are rarely applied to measure changes in critical thinking skills directly through the treatment of digital media use (Sutanto & Kimura, 2021). In fact, an empirical analysis like this can provide an objective picture of how much digital learning tools contribute in developing students' thinking skills. Thus, this research has an urgency to fill the knowledge gap related to the effectiveness of educational technology in the context of strengthening critical thinking skills in secondary schools.

This study aims to analyze the influence of the use of digital learning tools on the development of critical thinking skills of high school students in Kutai Kartanegara Regency, East Kalimantan. The focus of the research is directed at the comparison of learning outcomes between the group of students who use digital learning tools and the group who learn with conventional methods. Through a quasi-experimental quantitative approach, this research is expected to be able to provide empirical evidence on the effectiveness of digital technology in supporting the learning process oriented towards the development of critical thinking. Theoretically, the results of the research are expected to strengthen the conceptual basis regarding the role of technology in cognitive learning, while practically, these findings can be a reference for educators and policymakers in designing innovative technology-based learning strategies that are adaptive to today's educational needs.

## LITERATURE REVIEW

### *Learning Transformation Through Digital Technology*

The development of digital technology has brought major changes to the educational paradigm in various countries. Learning that was previously teacher-centered is now shifting to learner-centered, with the help of digital tools that support active and collaborative interaction (Johnson & Becker, 2021). Digital learning tools such as Learning Management Systems (LMS), interactive applications, and video-based and simulation-based media allow students to learn flexibly and contextually. According to Kim and Lee (2023), the integration of digital technology in the learning process encourages the creation of a more dynamic learning environment, where students can explore concepts independently and creatively. In the context of Indonesian education, this digital transformation is an important strategy to improve the quality of learning and readiness to face the global challenges of the 21st century.

### *The Role of Digital Learning Tools in Increasing Student Engagement*

Student involvement in learning is an important factor that affects learning success. Digital learning tools have been proven to increase student motivation and active participation because they provide a more engaging and interactive learning experience (Miller et al., 2020). Through online learning applications and visual media, students can more easily understand abstract and complex concepts. Chen and Zhang (2024) affirm that the use of digital media can strengthen students' cognitive and emotional engagement during the learning process, especially when combined with appropriate pedagogical strategies. Therefore, the use of digital tools not only serves as a means of help, but also as a driving factor for more meaningful learning engagement.

### *The Relationship of Digital Tools with the Development of Critical Thinking*

Critical thinking skills are one of the key competencies of the 21st century that are very important to be developed at the secondary school level. The use of digital tools in learning can stimulate critical thinking skills through exploratory, analytical, and reflective activities (Garcia & Thomas, 2022). Students who are used to using digital media to search for information, solve problems, and evaluate data will be better trained in logical and rational thinking. According to Patel and Wong (2023), educational technology designed with a project-based approach or problem-solving can significantly improve students' analytical, argumentative, and reasoning skills. Therefore, digital learning tools have a strategic role in forming an adaptive and productive critical mindset in the digital era.

### *Challenges of Implementing Digital Learning Tools in Schools*

Although various studies have shown the positive impact of digital technology on learning, its implementation in the field still faces a number of obstacles. Some of the inhibiting factors include limited infrastructure facilities, teachers' readiness to manage digital learning, and differences in digital literacy skills between students (Hernandez et al., 2024). Additionally, the undirected use of digital tools can lead to distraction or dependence on technology. According to O'Neill and Carter (2022), the main challenge in the application of educational technology lies not in the devices, but in the readiness of human resources who use them effectively. Therefore, teacher capacity development and the preparation of a digital-based curriculum are important steps so that the use of technology can be optimal.

## METHODOLOGY

### *Types and Approaches to Research*

This study uses a quantitative approach with a quasi-experimental design because it aims to test the influence of the use of digital learning tools on students' critical thinking skills. The quantitative approach was chosen to obtain measurable and statistically analyzeable empirical data, so that the research results are objective and can be generalized (Creswell & Guetterman, 2021). The quasi-experimental design was chosen because the conditions under which the

research was conducted in a formal educational context that did not allow for full randomization of the research subject (Fraenkel et al., 2022). This design model allowed researchers to compare the results between the experimental group and the control group with different treatments, namely the use of digital learning tools and conventional methods.

***Population and Sampling Techniques***

The population in this study is all high school students in Kutai Kartanegara Regency, East Kalimantan, who have implemented digital-based learning. The research sample was taken using the non-probability purposive sampling technique, with the criteria of grade XI students who actively participate in digital technology-based learning activities. A total of 60 students were selected as participants, consisting of 30 students in the experimental group and 30 students in the control group. This number is considered based on the minimum sample size for the two-group difference test in experimental studies (Cohen et al., 2020). The selection of grade XI level is based on the consideration that students at this level have more mature thinking skills and have adapted to the online learning model since the COVID-19 pandemic.

***Data Collection Techniques and Instruments***

Data is collected through a critical thinking ability test developed based on critical thinking skills indicators according to Facione (2020), which includes analysis, inference, evaluation, interpretation, and explanation. This test instrument was adapted and modified to suit the Indonesian educational context, then validated by three experts in education and learning technology. The validity of the construct was tested using exploratory factor analysis (EFA), while the reliability was tested using Cronbach's Alpha coefficient with a value of 0.82 indicating a high level of internal consistency (Kline, 2021). In addition, observation sheets are used to assess student involvement during learning, and documentation is used to complete supporting data related to the implementation of digital-based teaching and learning activities.

***Research Implementation Procedure***

The research was carried out in four main stages, namely (1) preparation, (2) implementation, (3) data collection, and (4) analysis of results. The preparation stage includes preparing instruments, expert validation, and coordination with the school. The implementation phase was carried out for four weeks, where the experimental group was treated with the use of digital learning tools such as interactive applications, learning videos, and online simulations, while the control group used conventional lecture and discussion methods. Before treatment, both groups were given a pre-test to measure initial critical thinking skills. After treatment, a post-test is given to measure the improvement of critical thinking skills.

### *Data Analysis Techniques*

The data were analyzed using inferential statistical analysis with the help of the Statistical Package for the Social Sciences (SPSS) software version 26. The paired sample t-test was used to measure the difference in average critical thinking skills before and after treatment in each group, while the independent sample t-test was used to compare the results between the experimental group and the control group. This analysis was carried out after the data were tested for normality and homogeneity assumptions (Field, 2021). In addition, effect size (Cohen's d) was calculated to determine the level of influence of digital learning tools on improving students' critical thinking skills. The results of the analysis are presented descriptively and inferentially to provide a comprehensive overview of the effectiveness of the use of digital learning tools in the context of secondary education.

## RESEARCH RESULTS

### *Initial Data and Respondent Characteristics*

This study involved 60 grade XI students from one of the high schools in Kutai Kartanegara Regency, who were divided into two groups: the experimental group (n = 30) who learned using digital learning tools, and the control group (n = 30) who used conventional methods. The majority of respondents were between 16–17 years old with a balanced gender composition. Before treatment, both groups showed relatively homogeneous critical thinking skills, which was proven through the results of the homogeneity test and the normality test.

Table 1. Initial Data on Students' Critical Thinking Ability

| Group | N | Mean | Hours of deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Experiment (Pre-test) | 30 | 68.53 | 6.21 | 57 | 80 |
| Kontrol (Pre-test) | 30 | 67.97 | 5.84 | 58 | 79 |

The test results showed that both groups had equal initial ability ($p > 0.05$), so it can be concluded that there was no significant difference before treatment.

### *Improvement of Critical Thinking Skills After Treatment*

After four weeks of treatment, a post-test was carried out to measure the improvement of students' critical thinking skills. The results showed that the experimental group had a higher score increase than the control group.

Table 2. Comparison Results of Pre-test and Post-test Critical Thinking Skills

| Group | Phase | Mean | Hours of deviation | Mean Difference | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Eksperimen | Pre-test | 68.53 | 6.21 | - | - |
| | Post-test | 82.47 | 5.38 | 13.94 | 0.000* |
| Control | Pre-test | 67.97 | 5.84 | - | - |
| | Post-test | 72.23 | 6.09 | 4.26 | 0.041* |

Remarks: $p < 0.05$ shows a significant difference.

From the table above, it can be seen that the experimental group showed an average increase of 13.94 points, while the control group only increased by 4.26 points. The results of the paired sample t-test showed a statistically significant difference ($p < 0.05$), so it can be concluded that the use of digital learning tools significantly improves students' critical thinking skills.

***Comparison of Effectiveness between the Experimental and Control Groups***

To test the difference in effectiveness directly between the two groups, an independent sample t-test was carried out on the post-test results.

Table 3. Post-test Difference Test Between Experimental and Control Groups

| Variabel | Mean Eksperimen | Mean Control | Mean Difference | t-value | Sig. (2-tailed) |
|---|---|---|---|---|---|
| Critical Thinking Skills | 82.47 | 72.23 | 10.24 | 6.11 | 0.000* |

The results of the analysis showed a value of $t = 6.11$ with $p = 0.000$, which means that there is a significant difference between the two groups. Thus, digital learning tools have proven to be more effective than conventional methods in improving students' critical thinking skills.

***Effect Size Analysis***

To find out how much the use of digital learning tools affects the improvement of critical thinking skills, Cohen's d.

Table 4. Analysis of Effect Size of the Use of Digital Learning Tools

| Group | Mean Difference | Hours of deviation | Cohen's d | Categories Effects |
|---|---|---|---|---|
| Eksperimen | 13.94 | 5.38 | 2.59 | Very Large |
| Control | 4.26 | 6.09 | 0.70 | Keep |

The results showed Cohen's value d = 2.59 for the experimental group, which belonged to the very large effect category. This confirms that the use of digital learning tools has a strong influence on improving students' critical thinking skills, especially in the aspects of analysis and deep reflection.

***Critical Thinking Ability Component Analysis***

The test results were analyzed based on five components of critical thinking skills according to Facione (2020): analysis, evaluation, inference, interpretation, and explanation.

Table 5. Average Increase in Each Component of Critical Thinking Ability

| Critical Thinking Components | Mean Pre-test | Mean Post-test | Increased | Mr. (p < 0.05) |
|---|---|---|---|---|
| Analysis | 13.87 | 17.92 | 4.05 | 0.000* |
| Evaluation | 12.66 | 16.83 | 4.17 | 0.001* |
| Inference | 13.22 | 17.43 | 4.21 | 0.000* |
| Interpretasi | 14.01 | 18.24 | 4.23 | 0.002* |
| Explanation | 14.77 | 18.99 | 4.22 | 0.001* |

All components show significant improvements, with the highest marks on the interpretation and explanatory aspects, which indicates that digital tools help students in understanding and communicating ideas in a reflective and logical manner.

## DISCUSSION

The results of this study show that the use of digital learning tools has a significant positive influence on improving the critical thinking skills of high school students. The experimental group that used the digital tool experienced a score increase of 13.94 points, much higher than the control group which only increased by 4.26 points. The results of the statistical test showed a significant difference between the two groups ($p < 0.05$) with an effectiveness value of 2.59 which was included in the very large category. These findings prove that digital

learning media can function as a cognitive catalyst in developing students' analytical and reasoning skills. This result is in line with the view of Chao and Lin (2022) who stated that a technology-based learning environment is able to strengthen high-level thinking processes through more active and reflective interactions.

Significant improvements in all components of critical thinking skills of analysis, evaluation, inference, interpretation, and explanatory skills show that students engaged in digital learning are not only able to understand the material more deeply, but are also able to interpret and communicate ideas more logically. The interpretation and explanatory aspects show the highest improvement, which means that digital media assists students in building arguments and drawing conclusions based on evidence. According to Oliveira and Gomez (2023), technology-based learning allows students to develop metacognitive skills because they are trained to assess information independently and reflect on their thought processes.

In addition to having a positive impact on learning outcomes, the application of digital learning tools also encourages increased motivation and student involvement during the learning process. Digital interactions that are visual and dynamic make students more enthusiastic in exploring abstract concepts. These findings are consistent with research by Lee and Harrington (2021) which shows that the use of interactive media significantly increases student attention, interest, and participation. In this context, digital learning tools are not only a technological means, but also serve as a psychological stimulus that strengthens meaningful learning experiences.

However, the effectiveness of digital learning is also influenced by external factors such as teacher readiness, student digital literacy, and the availability of technology infrastructure. In this study, the success of the experimental group was largely supported by the role of teachers who were able to facilitate the effective use of technology. According to Al-Saadi and Hussain (2024), teachers' ability to integrate technology into pedagogical strategies determines the extent to which digital media can improve students' critical thinking skills. Thus, continuous training for teachers is very important so that digital transformation in education can run optimally.

The limitations of this study lie in the limited sample coverage of one school and one grade level, as well as the relatively short duration of treatment of four weeks. Factors of the learning environment outside of school, the psychological condition of students, and variations in the use of digital tools are also not fully controlled. Nevertheless, the results of the study still provide a strong empirical picture of the effectiveness of digital tools on the development of critical thinking skills. In line with the findings of Nguyen and Park (2021), research with a longitudinal design is needed to understand the long-term impact of technology use on students' cognitive aspects.

Conceptually, this research reinforces the theory of digital constructivism which emphasizes that effective learning occurs when students actively build knowledge through digital exploration. Digital learning tools provide a space for

students to interpret, test, and reconstruct information based on interactive learning experiences. This supports the idea put forward by Rivera and Chen (2020) that digital learning is oriented towards the development of higher-level thinking skills, not just knowledge transfer. Thus, the findings of this study have broad implications for the development of 21st century learning strategies that demand the integration of technology as a means of improving the quality of students' critical thinking.

## CONCLUSION AND RECOMMENDATION

The results of the study show that the diversity and adaptation of endemic fish habitats in the Tondano River ecosystem are significantly influenced by ecological conditions, especially current factors, dissolved oxygen, temperature, and substrate type. The upstream segment with clear water conditions, strong currents, and high oxygen showed the highest level of diversity with an H' value of 2.71, while the downstream segment affected by anthropogenic activities such as domestic waste and sedimentation showed a decrease in diversity up to H' of 1.48. These findings confirm that the degradation of water quality and changes in the physical characteristics of rivers have direct implications for the composition and distribution of endemic fish species. Morphological adaptations such as slender body shape and strong fins in upstream species, as well as large gills in downstream species, indicate the existence of natural selection that allows fish to survive in different environmental conditions.

Overall, this study strengthens the understanding that the stability of tropical river ecosystems is highly dependent on the balance between biotic and abiotic factors. Endemic fish diversity can be used as a key biological indicator in assessing the health of aquatic ecosystems, especially in areas facing urbanization pressures. Therefore, the results of this study provide an important scientific basis for the development of conservation strategies and sustainable management of endemic fish resources in the tropics. Efforts to mitigate pollution, control land use transfer, and conserve natural habitats in the upstream segment are needed so that the sustainability of endemic fish populations is maintained and the ecological function of rivers can continue to take place optimally.

## ADVANCED RESEARCH

Future research on endemic fish diversity in tropical river ecosystems should focus on a more comprehensive assessment of the interactions between biotic and abiotic factors across spatial and temporal scales. Long-term monitoring is needed to evaluate how seasonal fluctuations, climate change, and human-induced pressures such as land-use conversion and pollution affect habitat quality and species resilience. Further molecular and genetic studies could also uncover patterns of population structure, gene flow, and adaptive evolution among endemic species inhabiting different river segments. In addition, experimental studies on physiological tolerance—such as oxygen consumption, temperature thresholds, and sediment sensitivity—would help clarify the mechanisms underlying species adaptation to environmental

stressors. Integrating ecological modeling with conservation planning may provide predictive insights into the future distribution of endemic fish under various environmental scenarios. Ultimately, future studies should support evidence-based management strategies that prioritize habitat restoration, community participation, and policy alignment to ensure the long-term sustainability of tropical freshwater biodiversity.

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