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Implementation of Virtual Reality Media with MilleaLab Platform in Computational Thinking Competence

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Abstract

The advancement of digital technology requires sufficient computational cognitive skills, particularly in high school Computer Science subjects. However, there is a gap between these demands and the current computational thinking abilities of students, which remain relatively low. This study aims to develop effective learning media to enhance the computational cognitive skills of high school students in Computer Science subjects. The research method focuses on the development of virtual reality media using the Millealab platform, accessible through Android devices. The feasibility, practicality, and effectiveness of the media were tested through validation by media experts (Millealab) and subject matter experts (Computer Science teachers from SMAN 1 Cigombong), along with trials conducted with teachers. Results from the media expert validation showed an average score of 4.44 (highly feasible), while the subject matter expert received an average score of 3.57 (feasible). The practicality test conducted by users (teachers and students) resulted in an average score of 90.97% (highly practical). The effectiveness test, based on pretests and posttests, revealed a significant improvement in the cognitive performance of students. This study concludes that the developed virtual reality media is highly feasible, very practical, effective, and significantly improves the computational cognitive skills of students, especially in the computational thinking aspect of Computer Science. The development of comprehensive virtual reality-based learning media for Computer Science offers an innovative solution to address the gap in computational thinking abilities, providing an immersive learning experience and contributing positively to the quality of education.

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INTRODUCTION

The rapid advancement of digital technology has created a demand for individuals to possess strong computational thinking skills, as the complexity of computing continues to grow alongside the relentless evolution of science and technology (Puspitorini et al., 2022). Computational thinking skills are not only relevant for computer scientists but also serve as an essential foundation for everyone in facing the digital age (Hidayat et al., 2020). This skill is particularly important in education, especially for the Informatics subject at the senior high school level. Learning in the 21st century demands mastery in critical thinking, collaboration, communication, and creativity, where technological literacy becomes a key component for accessing information from various sources (Winarni et al., 2020). Currently, there is a significant gap between the demands of the digital world and the computational thinking abilities of students. This gap is evident from the difficulties students face in solving complex problems, identifying patterns, abstracting concepts, and systematically formulating problem-solving steps. Field observations indicate that student interest and competence are still low, highlighting the need for more meaningful learning innovations to improve conceptual understanding (Lestari et al., 2020).

Various research efforts have been made to address this gap, but few focus on holistic learning approaches such as immersion, visualization, high interactivity, personalization, and the integrated enhancement of student motivation and interest. The application of comprehensive computational thinking requires an approach that extends beyond a single field of study. Virtual reality offers an immersive and interactive learning experience that can increase student motivation and engagement. The use of technology like virtual reality can turn imagination into reality, opening opportunities for lifelong learning that is not bound by time and space (As et al., 2022). However, the use of virtual reality in education, especially for developing computational cognitive abilities, remains limited. Virtual reality is increasingly recognized as a relevant approach to prepare students for the challenges of the 21st century by providing immersive and interactive learning experiences (Budiyono & Haerullah, 2024). Thus, integrating this technology not only enriches teaching methods but also encourages students to develop critical thinking and adaptive problem-solving abilities (Mardhiyah et al., 2021).

Mukhopadhyay stated that virtual reality offers an immersive and interactive learning experience, thus enhancing student motivation and involvement (Mukhopadhyay et al., 2022). However, most of these studies focus on specific disciplines, such as mathematics or science. This virtual reality medium effectively guides students from remembering and understanding to applying knowledge interactively (Arif Hidayat et al., 2024). The use of this medium also provides a more personalized and deeper learning experience, tailored to the unique learning needs and preferences of each student (Maulidia & Prafitasari, 2023). Through the integration of advanced technology, students can directly interact with abstract concepts, facilitating a deeper and more applicable understanding, in line with the technological literacy needs of the digital age (Budiyono & Haerullah, 2024).

Therefore, this research focuses on developing a virtual reality-based learning medium as an innovative solution to enhance the computational competence of students, particularly in the elements of computational thinking, which are essential 21st-century skills (Mantau & Talango, 2023). The main goal is to improve the cognitive computational abilities of students in the Informatics subject in class XI at SMA Negeri 1 Cigombong. Unlike previous studies that may have only focused on three-dimensional visualization, this research will design a more interactive virtual reality experience, involving students in problem-solving, decision-making, and design. The developed framework will include stages of planning, design, development, implementation, and evaluation, considering factors such as software selection, learning content design, and appropriate evaluation methods.

METHODOLOGY

This research uses the Research and Development (R&D) method, adopting the ADDIE Model (Analysis, Design, Development, Implementation, Evaluation) to develop Virtual Reality media (Muti'ah et al., 2022). The ADDIE model is chosen because of its systematic and structured phases, which support the development of effective and efficient learning media. This model includes five main phases: Analysis, Design, Development, Implementation, and Evaluation (Tambunan et al., 2021). The ADDIE model ensures that each development phase is based on clearly identified needs and designed to achieve specific learning objectives. The primary focus is to test the effectiveness of this VR media in improving the computational cognitive abilities of students. The effectiveness of the VR media is tested during the Implementation and Evaluation phases of the ADDIE model, applied to two groups of students: the control group and the experimental group. This experimental design uses a quantitative approach to compare the improvement in computational competence between the two groups, ensuring the validity and reliability of the findings (Nuraydah et al., 2023).

The experimental group consists of class XI students from SMAN 1 Cigombong who will receive learning treatment using virtual reality media, while the control group consists of class XI students from SMAN 1 Caringin who will not receive learning treatment using virtual reality media. Both groups (experimental and control) will take a pre-test with the same set of questions to measure their initial cognitive abilities and ensure that both groups have comparable skills before the treatment. A post-test will then be administered to both groups after the treatment to evaluate the improvement in the computational competence of students. In the context of this development, the ADDIE model allows for material adjustment based on curriculum and student needs analysis and involves validation by language and media experts to ensure the feasibility of the final product (Ekawati et al., 2022).

To collect data on effectiveness, this study uses a test to assess the effectiveness of the virtual reality media. The instrument consists of pre-test and post-test questions that are identical for both groups (Purwaningsih et al., 2024). These questions are designed to measure the computational cognitive abilities of students. The validity of the effectiveness instrument was pre-tested on other class XI senior high school students to ensure its reliability.

RESULTS AND DISCUSSION

Results

Based on the data analysis results, the researcher developed and evaluated virtual reality media to enhance the effectiveness of student computational abilities in the Informatics subject for class XI phase F. Measuring cognitive improvement in students is a crucial task. One statistical method commonly used to measure this improvement is the N-Gain Test (Normalized Gain). The N-Gain Test helps measure the effectiveness of a learning intervention by comparing pre-test and post-test scores, providing a more accurate indication of how much improvement occurred in student cognitive abilities after the treatment (Arifin et al., 2020) (Kismiati, 2020). This improvement is measured by comparing the average scores between the experimental group, which uses virtual reality media, and the control group, which does not use it (Maharani et al., 2023). This method specifically allows for evaluating the impact of an intervention in an educational context, providing quantitative insight into the efficiency of new learning interventions in enhancing cognitive abilities (Nurkanti et al., 2019). Data analysis for the N-Gain test involves calculating the normalized gain score for each student, which is then averaged for each group, allowing for the statistical identification of significant differences between the two groups.

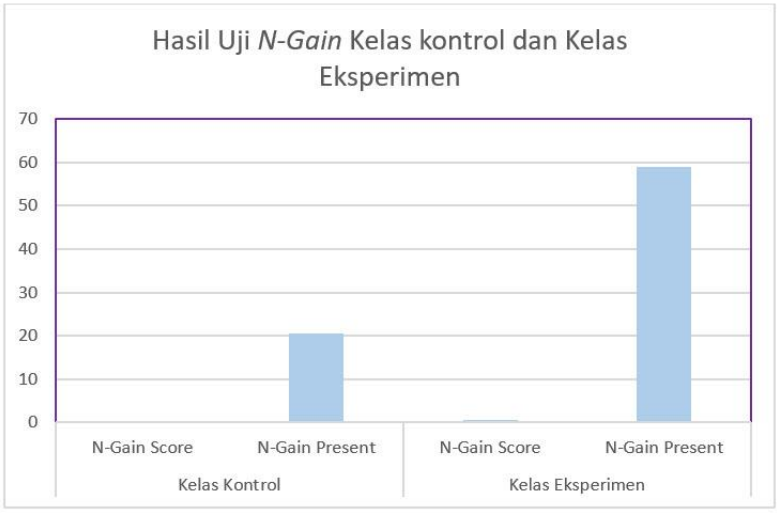
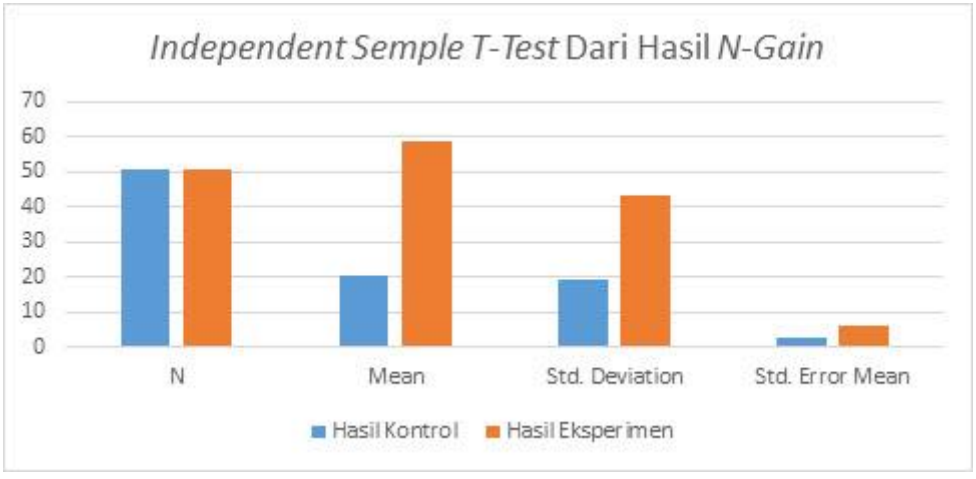


Figure 1. N-Gain Test Results Diagram

Based on the N-Gain test results for 50 students divided into the control and experimental groups, it was found that the average percentage improvement in the experimental group reached about 60%, much higher than the control group, which was only around 20%. This shows that the use of virtual reality media significantly improved students understanding and ability to apply the concepts they learned. This result aligns with previous research showing that interactive learning media have a substantial positive impact on student motivation and learning outcomes (Zebua & Harefa, 2022) (Syahida & Purba, 2022). Other studies also confirm that the use of technology-based learning media, such as audiovisual or interactive media, can significantly improve students learning outcomes (Khotimah, 2019). This effectiveness improvement correlates with findings that using experimental media can improve student learning outcomes by up to 88% and student activity by up to 90% (Ismijati, 2022).

This shows that the virtual reality media applied in the experimental class is moderately or quite effective in helping students understand and master the Informatics subject, particularly computational thinking elements, significantly from their initial state. To determine if there are significant differences, the method used involves comparing pre-test and post-test scores between the experimental and control groups using the independent sample t-test. This test is performed on the N-Gain percentages for the experimental and control groups. The results of the independent sample t-test can be seen in the appendix in the table showing the t-test output.



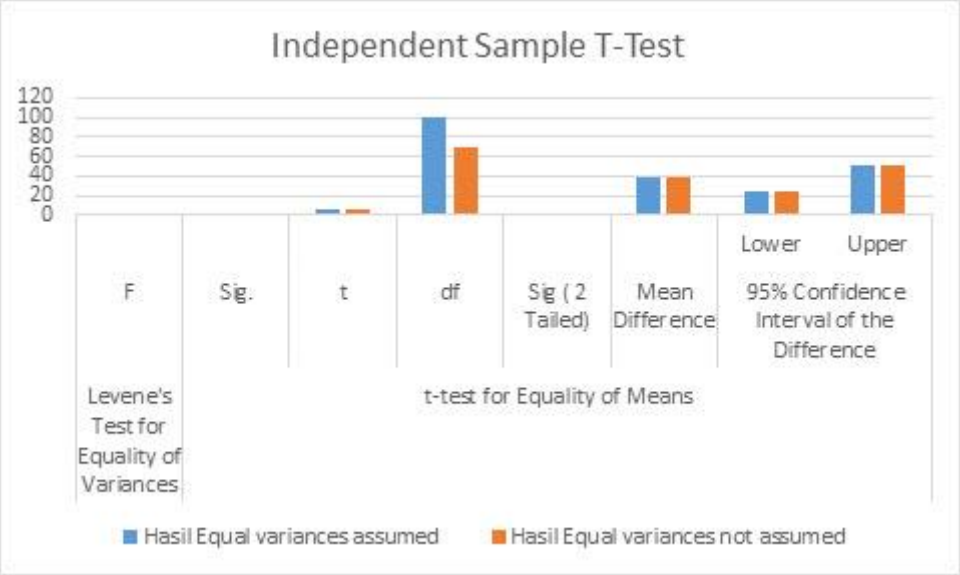


Figure 2. Independent T-Test Results Diagram Based on N-Gain Results

To assess the effectiveness of using virtual reality media to improve student learning outcomes, statistical analysis using an independent sample t-test was conducted on the N-Gain percentages of the control and experimental groups. Descriptive statistics calculations show that the average N-Gain percentage for the control group is 20%, with a standard deviation of around 15%, while for the experimental group, the average N-Gain percentage reaches 60%, with a standard deviation of around 35%. The standard error mean values for both groups are relatively small, indicating that the average estimates are stable.

Before analyzing the mean differences, Levene's Test for Equality of Variances was first conducted to determine if the variances between the two groups could be considered homogeneous. The Levene's test results show a significance value (Sig.) > 0.05, meaning there is no significant difference in variance between the two groups. Therefore, the assumption of equal variances can be used in the t-test analysis.

Subsequently, the t-test for Equality of Means shows a significance value (2-tailed) < 0.05, indicating that there is a statistically significant difference between the mean N-Gain percentages of the control and experimental groups. This significant mean difference is also supported by the confidence interval (CI 95%) in the Lower-Upper column, which does not cross zero, meaning that the difference between the two means is genuine and not the result of random variation. This finding is consistent with previous research showing that innovative and technology-based learning interventions, such as the Blended Learning model, significantly affect student learning outcomes, as evidenced by the low significance value in hypothesis testing (Nurismayanti & Maknun, 2022).

In general, these findings suggest that virtual reality media can provide a significant improvement in learning outcomes compared to conventional learning without such media. The average improvement of 60% in the experimental class compared to 20% in the control class is a strong indicator that using VR in interactive science or physics learning can guide students from basic understanding to the real-world application of concepts.

Discussion

Computational Thinking is a process that involves solving problems in a way similar to how computer scientists approach them. It includes four main pillars: decomposition (breaking down complex problems into smaller parts), pattern recognition (identifying similarities in problems), abstraction (focusing on important details), and algorithms (developing steps for solutions). This skill is essential in the digital era, not only for Informatics but also for many other disciplines. In project-based learning, computational thinking is

a fundamental skill that students must acquire to achieve the learning objectives.

In project-based learning, media is needed to stimulate students and encourage them to engage in research related to the projects they will discuss. Learning media refers to any form of tool, material, or technology used to facilitate the teaching and learning process. Its goal is to convey information, stimulate thinking, and foster interaction between educators and students. Effective learning media can make material easier to understand, engaging, and relevant, thus supporting the achievement of learning goals (F. Sekar Hayu Dewani et al., 2023).

Virtual Reality (VR) is a technology that creates an immersive experience for users by simulating a three-dimensional environment that they can interact with. Users typically wear special devices such as VR headsets to experience the sensation of being in a digital environment. In education, VR has great potential to visualize abstract concepts, conduct virtual experiments, or take virtual field trips to places that are difficult to reach, thereby increasing student engagement and understanding.

The virtual reality media developed in this study uses the Millealab platform to improve the cognitive abilities of students in computational thinking within the Informatics subject for class IX in senior high school. The development process follows the ADDIE model, which consists of five stages: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Alodwan & Almosa, 2018). The virtual reality media developed by the researcher is cloud-based. The use of online media or internet-based media is one solution to help students better understand learning material.

The effectiveness of the developed virtual reality media is linked to the goal of improving learning quality. This study aims to enhance student cognitive performance in Informatics, specifically in computational thinking, based on pre-test and post-test results from the students. The data analysis indicates that the developed virtual reality media is quite effective and significantly applicable in the learning process. This supports prior research, which suggests that learning innovations using virtual reality media can positively impact the improvement of student computational skills, especially in abstract subjects (Sriwahyuni et al., 2020).

CONCLUSION

Based on the research results and discussion in this study, it can be concluded that: (1) The development of virtual reality media for computational thinking material using the ADDIE model has been completed and tested. (2) The developed virtual reality media is highly suitable for use in the learning process. (3) The virtual reality media enhances the effectiveness of learning in computational thinking material within the Informatics subject for class XI phase F. (4) There is a significant improvement in student cognitive abilities, greater than the improvement observed using conventional teaching methods. Technological innovations, such as virtual reality media, have proven to make a positive contribution to the learning process by providing an interactive and engaging learning environment.

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