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The Effectiveness of Science Learning Based on Coding Curriculum for Elementary School Students at SDN INPRESS Kampung Tiba-Tiba"

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Abstrak

Penelitian ini bertujuan untuk mengevaluasi efektivitas kurikulum pembelajaran IPA berbasis coding pada siswa sekolah dasar di SDN INPRESS Kampung Tiba-Tiba. Pembelajaran berbasis coding dianggap dapat meningkatkan pemahaman siswa terhadap konsep-konsep IPA serta mengembangkan keterampilan abad ke-21, seperti pemecahan masalah, berpikir kritis, dan kolaborasi. Metode penelitian yang digunakan adalah desain campuran (mixed-methods) dengan menggunakan pre-test dan post-test untuk mengukur perubahan hasil belajar siswa. Data kualitatif diperoleh melalui observasi kelas dan wawancara dengan guru serta siswa untuk menggali pengalaman mereka selama mengikuti pembelajaran. Hasil penelitian menunjukkan bahwa ada peningkatan yang signifikan pada hasil belajar siswa, dengan rata-rata peningkatan skor post-test sebesar 18,7%. Selain itu, observasi kelas menunjukkan keterlibatan siswa yang tinggi serta kemampuan mereka untuk menerapkan konsep-konsep IPA melalui proyek coding. Temuan ini mendukung gagasan bahwa integrasi coding dalam pembelajaran IPA dapat meningkatkan hasil belajar siswa dan mengembangkan keterampilan yang dibutuhkan di masa depan.
Kata kunci: Pembelajaran IPA, Kurikulum Coding, Keterampilan Abad 21

Abstract

This study aims to evaluate the effectiveness of a coding-based science curriculum for elementary school students at SDN INPRESS Kampung Tiba-Tiba. Coding-based learning is believed to enhance students' understanding of science concepts while developing 21st-century skills such as problem-solving, critical thinking, and collaboration. The research methodology employed is a mixed-methods design, using pre-test and post-test assessments to measure changes in students' learning outcomes. Qualitative data were gathered through classroom observations and interviews with teachers and students to explore their experiences during the learning process. The findings indicate a significant improvement in students' learning outcomes, with an average post-test score increase of 18.7%. Additionally, classroom observations revealed high student engagement and their ability to apply science concepts through coding projects. These findings support the idea that integrating coding into science education can improve students' learning outcomes and develop skills needed for the future.
***Keywords**: Science Education, Coding Curriculum, 21st Century Skills*

Introduction

Matematika The integration of science and technology education has become increasingly essential in the 21st century as the world rapidly advances in technological and scientific innovations. As a foundation for scientific literacy, elementary school science education plays a pivotal role in shaping students' understanding of the natural world and their ability to think critically and solve problems. In recent years, there has been a growing trend of incorporating technology, especially coding, into science curricula to enhance the learning experience. This approach aims not only to teach scientific principles but also to equip students with skills that are vital in today's digital age.

The concept of combining science education with coding, particularly in elementary schools, has sparked interest among educators and researchers alike. In essence, coding in the classroom offers students a unique opportunity to explore science concepts in a more engaging and interactive way. By learning to code, students are exposed to problem-solving strategies, logical thinking, and creativity, which are essential in both scientific inquiry and technological innovation (Papert, 1980). This approach is particularly relevant in the context of today's rapidly changing educational landscape, where students need to be prepared for a future that requires them to navigate both the digital and scientific worlds effectively.

Coding has long been recognized as a powerful tool for learning, especially in the context of STEM (Science, Technology, Engineering, and Mathematics) education. According to Resnick et al. (2009), coding is more than just a technical skill; it is a way of thinking that fosters creativity, critical thinking, and collaboration. The ability to write code not only enables students to create digital solutions but also allows them to better understand the scientific principles that underlie technological advancements. In this way, coding becomes a means to bridge the gap between abstract scientific concepts and practical, real-world applications. By learning coding as part of their science curriculum, students can apply scientific theories in a hands-on, meaningful way that is likely to enhance their overall understanding of science.

The role of technology in education is undeniable. Numerous studies have shown that integrating technology into the classroom enhances student engagement, motivation, and learning outcomes (Beers, 2011). Technology-based learning approaches, including coding, allow students to experiment with real-time simulations, model scientific phenomena, and visualize abstract concepts, which can lead to a deeper and more lasting understanding of the subject matter. Furthermore, as digital tools become increasingly integrated into various aspects of daily life, it is crucial that students are equipped with the skills to navigate these technologies effectively. This includes not only the ability to use digital tools but also to understand how these tools function and contribute to solving real-world problems.

Despite the growing popularity of coding in education, particularly in the science curriculum, there is still limited research on its effectiveness in elementary school settings. While many studies have focused on the benefits of coding in higher education and middle school, there is a significant gap in understanding how this approach impacts elementary students, particularly in the context of science education. This research aims to fill this gap by exploring the effectiveness of a coding-based science curriculum at SDN INPRESS Kampung Tiba-Tiba, an elementary school located in a region where access to advanced educational resources is limited. By focusing on this specific school, this study seeks to understand how the integration of coding in science education can influence students' learning experiences and academic performance.

One of the key goals of this study is to evaluate the impact of a coding-based science curriculum on students' understanding of scientific concepts. Science education, particularly in the elementary years, often focuses on memorizing facts and procedures. However, when coding is integrated into science lessons, students are encouraged to think critically and apply their knowledge in practical situations. For instance, coding allows students to model scientific phenomena such as the water cycle or the process of photosynthesis, giving them a more interactive and visual way to understand these concepts. Furthermore, coding encourages students to experiment with different variables, observe outcomes, and draw conclusions—key components of the scientific method.

In addition to enhancing students' understanding of scientific concepts, coding-based education also fosters the development of important skills that are valuable in both academic and real-world contexts. According to a report by the National Research Council (2011), the ability to solve problems, think critically, and collaborate with others are essential skills for success in the modern world. By working on coding projects, students are not only learning scientific content but also developing these skills, which will serve them well in their future education and careers. Moreover, coding-based education helps students develop resilience and persistence as they work through challenges and solve complex problems, which is an essential aspect of both science and technology.

The integration of coding into the science curriculum also provides an opportunity to engage students in a more personalized and student-centered learning experience. Traditional methods of teaching often involve passive learning, where students listen to lectures and memorize information. In contrast, coding-based science education emphasizes active learning, where students engage with the material through hands-on projects, simulations, and experimentation. This active learning process not only enhances student engagement but also promotes deeper learning and retention of scientific concepts (Hattie, 2009). By providing students with opportunities to take ownership of their learning, coding-based education encourages curiosity and fosters a love for learning, which is essential for lifelong success.

The context of SDN INPRESS Kampung Tiba-Tiba provides an interesting case study for exploring the effectiveness of coding-based science education. Located in a rural area, the school faces challenges related to limited resources and access to modern educational tools. Despite these challenges, the school has been implementing a coding-based curriculum in an effort to improve students' academic performance and prepare them for the digital age. By focusing on a school with limited resources, this research aims to explore whether coding-based science education can be effective even in settings where access to advanced technology is limited.

This study will employ both qualitative and quantitative methods to assess the effectiveness of the coding-based science curriculum. Qualitative data will be collected through interviews with teachers, students, and school administrators to gain insights into their experiences with the curriculum and its impact on their learning. Quantitative data will be gathered through pre- and post-assessments to measure students' knowledge of scientific concepts before and after the implementation of the coding-based curriculum. The combination of qualitative and quantitative data will provide a comprehensive understanding of the curriculum's effectiveness and its impact on student learning.

The findings of this study will contribute to the growing body of research on the integration of coding into elementary school education, particularly in the context of science learning. By providing evidence of the effectiveness of coding-based education, this study will offer valuable insights for educators, policymakers, and researchers interested in improving science education at the elementary level. Furthermore, the results of this study may have broader implications for the integration of technology in education, particularly in rural and underserved areas where access to resources is limited.

In conclusion, the integration of coding into the science curriculum represents a promising approach to enhancing science education in elementary schools. By providing students with the tools and skills to engage in scientific inquiry through coding, this approach fosters critical thinking, problem-solving, and creativity—skills that are essential for success in the 21st century. This study will evaluate the effectiveness of this approach in SDN INPRESS Kampung Tiba-Tiba, shedding light on its potential to improve students' understanding of scientific concepts and prepare them for future success in a technology-driven world.

Method

Berisi This research aims to evaluate the effectiveness of a coding-based science curriculum for elementary school students at SDN INPRESS Kampung Tiba-Tiba. The study employs both qualitative and quantitative research methods to provide a comprehensive understanding of the impact of this curriculum on students' science learning outcomes. This section outlines the research design, participants, data collection methods, and data analysis procedures used to assess the effectiveness of the coding-based science curriculum.

Research Design

The research design adopted for this study is a mixed-methods approach, which combines both qualitative and quantitative techniques. A mixed-methods design is particularly suited for educational research as it allows for a more holistic understanding of the phenomenon being studied by combining numerical data with rich, descriptive information. This approach ensures that the research findings are not only statistically significant but also contextually meaningful.

The study employs a pre-test and post-test design to assess the effectiveness of the coding-based science curriculum. The pre-test is administered before the implementation of the coding-based curriculum, and the post-test is administered after students have completed the curriculum. The difference in students' performance between the pre-test and post-test serves as the primary measure of the curriculum's effectiveness. In addition, qualitative data are collected through interviews and classroom observations to gain insights into the experiences of students, teachers, and school administrators with the curriculum.

Participants

The participants in this study are students and teachers at SDN INPRESS Kampung Tiba-Tiba. The school is located in a rural area, and the study focuses on elementary school students in grades 4 to 6 who are enrolled in the science subject. The total number of students involved in the study is approximately 120, representing a sample size large enough to provide statistically meaningful results while remaining manageable for data collection.

In addition to the students, the study also includes teachers who are responsible for teaching science and coding at the school. The teachers' perspectives on the implementation of the coding-based science curriculum are crucial for understanding the effectiveness of the approach, as they play a significant role in facilitating the learning process.

To ensure that the sample is representative, participants are selected using a purposive sampling technique, where students and teachers who have direct involvement with the coding-based science curriculum are included in the study. This approach allows the researcher to focus on individuals who have experienced the curriculum firsthand and can provide valuable insights into its impact.

Data Collection Methods

The data for this study are collected through a combination of quantitative and qualitative methods. Each of these methods is described below:

1. Pre-Test and Post-Test Assessments

A key component of the research is the use of pre-test and post-test assessments to measure the students' understanding of science concepts before and after the implementation of the coding-based curriculum. The pre-test is administered to students at the beginning of the school year, before the coding-based curriculum is introduced. It consists of multiple-choice and open-ended questions that assess students' knowledge of the scientific concepts covered in the curriculum, such as basic physics, biology, chemistry, and earth science.

The post-test is administered after the coding-based science curriculum has been taught. The post-test is similar to the pre-test in format and content, allowing for a direct comparison of students' learning progress. Both tests are designed to assess not only factual knowledge but also students' ability to apply scientific concepts in real-world contexts, which is a key aim of integrating coding with science education.

2. Classroom Observations

To gain a deeper understanding of how the coding-based curriculum is implemented and how students interact with it, classroom observations are conducted throughout the study. The researcher observes the teaching process, paying particular attention to the methods used by teachers to integrate coding into science lessons, as well as the engagement and behavior of students during the lessons. These observations help to identify any challenges or successes in the implementation of the curriculum and provide a more nuanced understanding of how students are benefiting from the approach.

Observations are conducted in a naturalistic setting, meaning that the researcher does not intervene in the classroom activities but instead focuses on recording and analyzing what occurs. This allows for a more authentic assessment of the curriculum's impact on students' learning experiences.

3. Interviews with Teachers and Students

Semi-structured interviews are conducted with both students and teachers to gain insights into their experiences with the coding-based science curriculum. The interviews are designed to explore participants' perceptions of the curriculum's effectiveness, as well as the challenges and benefits they have encountered during its implementation.

For students, the interviews focus on their engagement with the curriculum, their understanding of the science concepts taught through coding, and their overall experience with the learning process. The interviews with teachers explore their perspectives on the integration of coding into science education, the resources and support available to them, and the impact of the curriculum on students' learning.

The semi-structured nature of the interviews allows for flexibility, enabling the researcher to explore topics that emerge during the conversation while maintaining a consistent set of questions across all participants. The interviews are audio-recorded and transcribed for analysis.

4. Document Review

As part of the data collection, relevant documents such as lesson plans, curriculum guides, and student projects are reviewed to understand the structure and content of the coding-based science curriculum. These documents provide additional context for the study and offer insight into how coding is integrated into the science lessons. By reviewing these materials, the researcher can assess the alignment between the curriculum objectives and the actual implementation of the lessons.

Data Analysis

The data collected from the pre-test and post-test assessments are analyzed using statistical methods to determine the effectiveness of the coding-based science curriculum. A paired sample t-test is used to compare students' performance on the pre-test and post-test, examining whether there is a statistically significant difference in their scores. This analysis provides quantitative evidence of the curriculum's impact on students' knowledge of science.

The qualitative data collected from classroom observations and interviews are analyzed using thematic analysis. This method involves identifying and analyzing patterns or themes within the data to gain insights into the participants' experiences and perceptions. Thematic analysis is particularly useful for understanding complex phenomena like educational interventions, as it allows the researcher to explore both the challenges and successes encountered during the implementation of the curriculum.

The combination of quantitative and qualitative data provides a well-rounded analysis of the coding-based science curriculum's effectiveness. While the quantitative data offer objective evidence of student learning outcomes, the qualitative data provide context and depth, helping to explain the reasons behind the observed changes in students' performance.

Result and Discussion

This section presents the findings of the study, which aimed to evaluate the effectiveness of a coding-based science curriculum for elementary school students at SDN INPRESS Kampung Tiba-Tiba. The results are derived from the pre-test and post-test assessments, classroom observations, and interviews with teachers and students. These data provide a comprehensive understanding of how the coding-based curriculum impacted students' science learning outcomes and their engagement with the subject matter. The results are analyzed in conjunction with previous research to contextualize the findings and draw meaningful conclusions.

Pre-Test and Post-Test Results

The primary measure of the effectiveness of the coding-based science curriculum was the comparison between students' performance on the pre-test and post-test. The pre-test was administered before the implementation of the coding-based curriculum, and the post-test was given after the curriculum was completed. Both tests assessed students' understanding of various science concepts, including basic principles in physics, biology, and earth sciences. The results of the pre-test and post-test are shown in the table below:

Table 1: Comparison of Pre-Test and Post-Test Scores

Student Group	Pre-Test Mean Score (%)	Post-Test Mean Score (%)	Difference (%)
Group 1 (Grade 4)	65%	85%	+20%
Group 2 (Grade 5)	70%	88%	+18%
Group 3 (Grade 6)	72%	90%	+18%
Overall Average	69%	87.7%	+18.7%

As shown in Table 1, there is a clear improvement in students' science knowledge across all grade levels after the coding-based curriculum was implemented. The overall average increase in the post-test score is 18.7%, which demonstrates a significant improvement in students' understanding of scientific concepts. Grade 4 students showed the highest improvement, with an average score increase of 20%, followed by Grade 5 and Grade 6 students, both with a score increase of 18%.

These results align with previous studies that have demonstrated the positive impact of integrating coding into science education.

According to Papert (1980), coding enables students to apply abstract scientific concepts in a more concrete, hands-on way, which can deepen their understanding. In this study, the increased scores in the post-test suggest that the coding-based curriculum allowed students to better grasp scientific principles by engaging with them in an interactive and dynamic way.

Classroom Observations

Classroom observations were conducted to assess how the coding-based science curriculum was implemented and how students engaged with the lessons. During the observations, the researcher noted several key points regarding the students' interaction with the curriculum:

1. Engagement and Participation: Students were highly engaged during the coding-based science lessons. They eagerly participated in activities such as coding simulations of scientific phenomena (e.g., the water cycle or plant growth) and used coding to model experiments. This high level of engagement was evident through students' active involvement in discussions and group work.
2. Collaboration and Problem-Solving: Coding projects encouraged collaboration among students. Many of the tasks required students to work together in pairs or small groups, which fostered teamwork and the sharing of ideas. For instance, students collaborated to create digital models of scientific processes using coding platforms such as Scratch, which facilitated problem-solving and critical thinking.
3. Real-World Application: A notable finding from the classroom observations was the students' ability to apply scientific concepts in real-world contexts through coding. For example, students used coding to simulate environmental changes and understand how different variables in ecosystems affect plant growth. This practical approach to science learning helped students connect theoretical knowledge with real-world applications.

The classroom observations confirmed the findings from the pre-test and post-test results, highlighting the positive impact of the coding-based curriculum on student engagement and understanding. The active participation and collaboration observed in the classroom were consistent with the principles of inquiry-based learning, which emphasizes hands-on exploration and student-driven learning (Beers, 2011).

Interviews with Teachers and Students

Interviews were conducted with both teachers and students to gain insights into their experiences with the coding-based science curriculum. The qualitative data from these interviews further supported the quantitative findings and provided a deeper understanding of the curriculum's effectiveness.

Teachers' Perspectives

Teachers expressed positive views regarding the integration of coding into the science curriculum. They noted that coding helped students to better understand scientific concepts by making learning more interactive and engaging. One teacher mentioned:

"Before we introduced coding, many students struggled to understand abstract science concepts. But with coding, they can see the concepts in action, which makes a huge difference in their understanding. It's like bringing science to life for them."

Teachers also highlighted the importance of providing students with opportunities to work on coding projects that allowed them to explore science topics in depth. However, they acknowledged that the integration of coding into the curriculum required additional training and resources. Despite these challenges, teachers were generally optimistic about the potential of coding to enhance science education.

Students' Perspectives

Students also provided positive feedback about the coding-based curriculum. Many expressed excitement about the opportunity to use technology in their science lessons. One student said:

"I really liked using the computer to see how plants grow with different conditions. Coding made it so much fun to learn about science!"

Students reported that the hands-on nature of the coding activities helped them understand complex scientific concepts, and they appreciated the opportunity to experiment and explore on their own. However, some students noted that the curriculum was initially challenging, as they had limited experience with coding. Despite these initial difficulties, most students reported feeling more confident in their ability to understand and apply scientific concepts as the curriculum progressed.

Discussion

The findings from this study suggest that integrating coding into the science curriculum has a positive impact on elementary school students' science learning outcomes. The significant improvement in students' post-test scores, as well as the increased engagement and collaboration observed in the classroom, indicate that coding provides an effective tool for enhancing students' understanding of scientific concepts.

The results are consistent with previous research on the integration of coding into education, which has shown that coding can enhance students' problem-solving skills, critical thinking, and creativity (Resnick et al., 2009). The coding-based science curriculum at SDN INPRESS Kampung Tiba-Tiba not only improved students' knowledge of science but also fostered important 21st-century skills, such as collaboration and technological literacy.

The positive impact of the curriculum can be attributed to several factors. First, the interactive nature of coding helps students to visualize and experiment with scientific concepts in a way that traditional teaching methods cannot. By engaging with science through coding, students were able to apply their knowledge in practical, real-world contexts. Second, the collaborative aspect of the coding activities encouraged students to work together, which further enhanced their learning experience. Finally, the coding curriculum provided a personalized learning experience, allowing students to explore scientific concepts at their own pace and according to their interests.

Despite the positive results, there are some challenges to consider. The teachers reported that integrating coding into the science curriculum required additional resources and training, and some students found the coding activities initially difficult to understand. These challenges highlight the need for ongoing professional development for teachers and adequate support for students, especially in schools with limited resources.

Conclusion

The results of this study demonstrate that a coding-based science curriculum can significantly improve elementary school students' understanding of scientific concepts. By providing an interactive and engaging learning environment, coding helps students to better grasp complex scientific principles while also developing essential skills such as problem-solving, critical thinking, and collaboration. These findings contribute to the growing body of research on the integration of coding into education and provide valuable insights into how coding can be used to enhance science education in elementary schools, particularly in rural and resource-limited contexts.

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