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Analysis of Science Literacy and Environmental Awareness of Elementary School Students Through the Use of STEM-Based Solar Sprinkle and Ecoburn Media in Science Learning

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Abstract: The purpose of this study is to examine the effectiveness of STEM-based learning media, namely Solar Sprinkle and Ecoburn, in enhancing science literacy and environmental awareness among elementary school students. This quantitative study employed a pre-experimental design with a one-group pretest-posttest involving 50 students. Data were collected using standardized instruments measuring science literacy and environmental awareness. The results indicated a significant overall improvement in both variables after the intervention. The findings suggest that interactive, STEM-oriented media can support the development of students' understanding of scientific concepts and foster greater awareness of environmental issues. In conclusion, the integration of Solar Sprinkle and Ecoburn in science learning proved effective in promoting science literacy and environmental responsibility in the primary education context.

Keywords: Ecoburn; Environmental awareness; Science literacy; Solar sprinkle; STEM

Introduction

Science education at the elementary school level has a very important role in shaping the basis of students' understanding of the natural world and technology (Bilianska & Yaroshenko, 2020). In the face of increasingly complex times, learning approaches that integrate various disciplines, such as STEM (Science, Technology, Engineering, and Mathematics), are increasingly considered effective in preparing students to face global challenges. STEM not only encompasses the teaching of science and technology, but also emphasizes the importance of integration between science, technology, engineering, and mathematics to understand natural phenomena more holistically and thoroughly (Nuraeni et al., 2024).

In Indonesia, environmental issues are becoming increasingly urgent. The country faces various challenges related to climate change, environmental degradation, and low environmental awareness among the younger generation. In this context, the STEM approach becomes highly relevant—not only for teaching scientific and technological concepts but also for fostering critical thinking, problem-solving, and innovation that can be applied to address real-world environmental problems. By integrating science, technology, engineering, and mathematics, STEM-based learning can serve as an educational solution that directly contributes to tackling environmental crises in Indonesia. Therefore, education that instills environmental awareness in students from an early age is crucial (Biancardi et al., 2023). One way to enhance science literacy and environmental awareness is by

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integrating learning media focused on environmentally friendly technologies, such as Solar Sprinkle and Ecoburn, within the context of STEM education.

The use of STEM-based media such as Solar Sprinkle and Ecoburn in science learning in elementary schools can provide a great opportunity to improve students' scientific understanding of renewable energy and sustainability. Solar Sprinkle, as an automatic garden sprinkler that uses solar energy, allows students to learn the basic concepts of renewable energy as well as its application in daily life, especially in efforts to handle air pollution (Gürbüz & Çalık, 2021; Tadena & Salic-Hairulla, 2021). Likewise, Ecoburn, which introduced the concept of waste processing using an environmentally friendly fuel method that produces little smoke, is a solution to the waste problem in the community. Ecoburn is an eco-friendly waste incinerator that uses water and used cooking oil as fuel. This combustion process generates minimal smoke, making it a sustainable solution that does not pollute the environment.

Previous studies have shown that STEM-based approaches can improve students' science literacy. The integration of locally-based education in STEM learning can improve students' understanding of scientific concepts and environmental issues. They also emphasized the importance of contextual-based education that involves the surrounding environment as part of the learning process. In addition, research by Widowati et al. (2021) also shows that the introduction of local wisdom and environment-based media in science learning can strengthen scientific concepts and at the same time build a deeper environmental awareness in students. However, despite efforts to integrate STEM education in schools, research on the use of media such as Solar Sprinkle and Ecoburn in Indonesia is still very limited. Moreover, research that focuses on the analysis of science literacy abilities and environmental awareness of elementary school students through the use of these two media in the context of science learning is still rare (Sukmawati et al., 2024).

This research is very relevant to the challenges faced in improving the quality of science education and environmental awareness of the younger generation. Indonesia, as a country with very high biodiversity but also vulnerable to environmental damage, needs a more effective educational approach in instilling environmental awareness in students (Apriliana & Sukmawati, 2021). Thus, this study will not only look at the extent to which STEM-based learning media can contribute to improving students' science literacy, but also in the formation of students' character who care about the environment.

On the other hand, students' science literacy in Indonesia still faces various challenges. Based on the latest PISA (Program for International Student Assessment) report in 2022, Indonesia ranks 74th out of 79 countries in science literacy, with a score significantly lower than the global average. This highlights the pressing need to improve the quality of science education in Indonesia, as the country lags behind many others in equipping its students with essential scientific knowledge and skills (Muthi'ah & Sukmawati, 2023; Sukmawati et al., 2022b). A low score in science literacy not only affects students' academic performance but also hinders their ability to address real-world problems, particularly in fields such as technology, engineering, and environmental sustainability. One way to improve science literacy is to introduce learning methods that are more interesting and relevant to the needs of students, one of which is through the use of environmentally friendly technology-based media.

Through this study, it is hoped that the extent to which the use of STEM-based media, especially Solar Sprinkle and Ecoburn, can play a role in improving science literacy and environmental awareness of elementary school students (Hanif et al., 2019; Wei et al., 2024). This research also aims to provide recommendations on integrating STEM-based media in science education curriculum, which is expected to contribute to the development of more sustainable and technology-based education that is environmentally friendly. In addition, this research is also expected to provide a basis for educators and policymakers to design more effective learning methods, which not only emphasize increasing scientific understanding, but also on the importance of awareness of global environmental issues (Septiyanto & Prima, 2024; Wahyu et al., 2020). Thus, this research contributes to the formation of a young generation that is academically intelligent and has high social and ecological responsibility, which is indispensable in facing future environmental challenges.

Method

This study uses a quantitative approach with experimental design (Fauziah & Sukmawati, 2023; Nurliana et al., 2023) to analyze the science literacy and environmental awareness abilities of elementary school students through the use of STEM-based Solar Sprinkle and Ecoburn media in science learning. This research was carried out in Indonesia, involving a sample of elementary school students who were selected purposively based on certain criteria, including students aged 9-12 years, who have participated in science learning within the last year, and who were willing to use STEM-based learning media. The research subjects consisted of elementary school students who

participated in science learning using STEM-based Solar Sprinkle and Ecoburn media (Ammar et al., 2024). The research sample was selected from several elementary schools in Indonesia, with a total sample of 50 students. In this study, only one group was used, namely an experimental group that used Solar Sprinkle and Ecoburn media in science learning. The concept of science that is the focus of this research is the concept of renewable energy and the environment.

The instruments used in this study include science literacy and environmental awareness tests. The science literacy test is designed to measure students' understanding and skills in the field of science, covering basic science concepts that are relevant to the medium used, both from the aspects of concepts, contexts, and attitudes of students' science concepts. The instruments developed were in the form of multiple-choice questions as many as 20 questions, 10 questions about science literacy and 10 questions about environmental awareness. The science literacy instrument assesses students' ability to apply scientific knowledge in real-life contexts, understanding of scientific processes, and ability to solve problems related to renewable energy and environmental sustainability. This environmental awareness instrument measures the extent to which students have awareness of environmental issues, such as understanding pollution, renewable energy, and waste management, as a form of a complete science understanding attitude. The questions are designed to assess both cognitive aspects (knowledge) and affective aspects (attitudes) of students towards the environment. The responses will be analyzed using a scoring system based on the correct answers to measure the students' science literacy and environmental awareness levels.

The research procedure begins with preparation, where training for teachers is carried out to prepare for the use of Solar Sprinkle and Ecoburn media in science learning. Then, the implementation of the experiment was carried out with an experimental group that participated in STEM-based science learning using Solar Sprinkle and Ecoburn media for one month. After the implementation of learning, data was collected through science literacy and environmental awareness tests given to students at the beginning (pretest) and end (posttest) of the experiment. The pretest was administered before the learning process to assess students' initial levels of science literacy and environmental awareness. The posttest was administered after the learning intervention to evaluate any changes or improvements in these areas.

Data analysis was carried out using stacking analysis from the Rasch model for science literacy and environmental awareness test data. Stacking analysis was used to compare students' science literacy and environmental awareness skills before and after participating in learning using STEM-based media (Ifdaniyah & Sukmawati, 2024; Muthi'ah & Sukmawati, 2023; Sukmawati & Wahjusaputri, 2024). This analysis method allows for the integration of multiple measurement scales and helps to assess the overall impact of the learning intervention by comparing the pretest and posttest results. The Rasch model was employed to measure the reliability and validity of the test items, ensuring that the results accurately reflect the students' learning progress in both science literacy and environmental awareness.

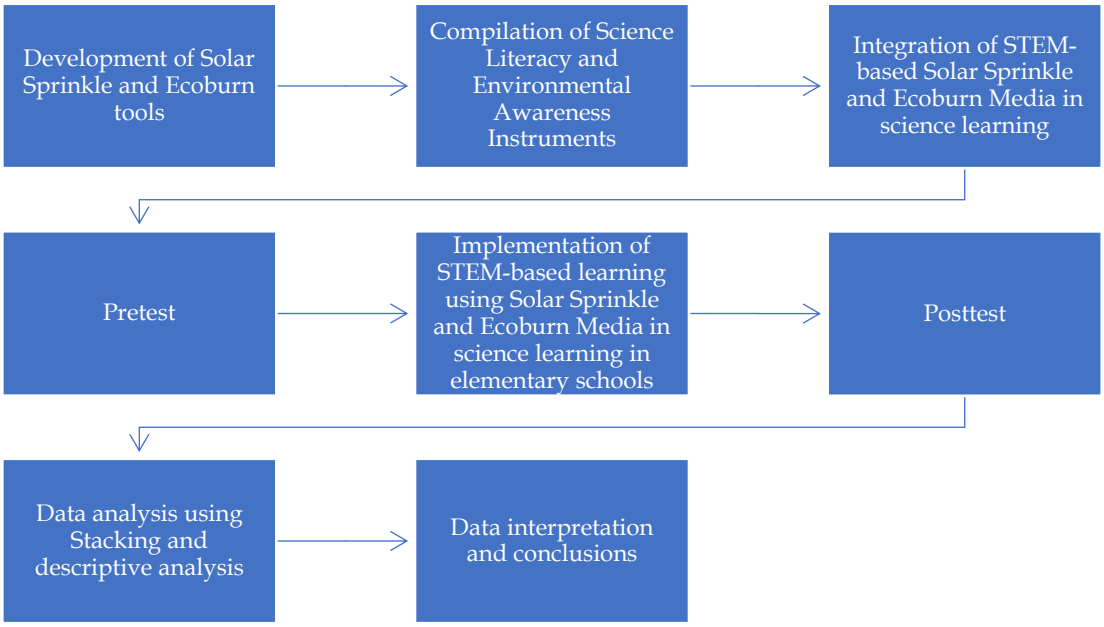

Figure 1. Research procedure

Result and Discussion

Result

Table 1. Changes in students' science literacy ability

Respond	Measure Science Literacy Ability		
	Pretest	Post-tests	Change
S1	0	1.4	1.4
S2	0.41	2.22	1.81
S3	-0.86	0.41	1.27
S4	-1.4	0.86	2.26
S5	0	0	0
S6	0	1.4	1.4
S7	0.86	3.49	2.63
S8	-0.41	2.22	2.63
S9	0	1.4	1.4
S10	0	1.4	1.4
S11	0	1.4	1.4
S12	0.41	2.22	1.81
S13	0.41	2.22	1.81
S14	0	2.22	2.22
S15	0.86	3.49	2.63
S16	0	3.49	3.49
S17	0	2.22	2.22
S18	-0.86	2.22	3.08
S19	0	1.4	1.4
S20	2.22	2.22	0
S21	-0.41	1.4	1.81
S22	0	2.22	2.22
S23	-1.4	0.86	2.26
S24	0.86	2.22	1.36
S25	0.41	2.22	1.81
S26	0	1.4	1.4
S27	0.86	2.22	1.36
S28	0.41	2.22	1.81
S29	0	1.4	1.4
S30	0	1.4	1.4
S31	-0.41	0.86	1.27
S32	0	0.86	0.86
S33	0.41	0.41	0
S34	-0.41	0.86	1.27
S35	-0.86	0.86	1.72
S36	0.86	2.22	1.36
S37	-0.86	1.4	2.26
S38	0.41	2.22	1.81
S39	-0.41	1.4	1.81
S40	-0.41	1.4	1.81
S41	0.86	2.22	1.36
S42	1.4	2.22	0.82
S43	0	0.86	0.86
S44	-0.41	0.86	1.27
S45	-0.41	0.86	1.27
S46	0.41	1.4	0.99
S47	0.86	2.22	1.36
S48	-0.86	0.86	1.72
S49	0.41	2.22	1.81
S50	-0.86	0.86	1.72

Based on the data provided regarding changes in the science literacy skills of students who participated in science learning with the theme of renewable energy and the environment using STEM-based learning media. such as Solar Sprinkle and Ecoburn. there was a significant variation in students' pretest and posttest results. These results reflect a shift in line with the educational theories underlying STEM-based learning (Anning, 2024; Rahmayani et al., 2024).

On the pretest. the majority of students showed inadequate results. reflecting a limited understanding of renewable energy and environmental concepts before accepting STEM-based learning (Schmid et al., 2021; Wahjusaputri & Nastiti, 2022). However. after being treated with interactive media-based learning. the posttest results showed a significant improvement. as seen in S7 and S15 students. who experienced a spike in scores of 2.63. This is in accordance with the theory of constructivism introduced by Jean Piaget and Lev Vygotsky. Piaget emphasized that effective learning occurs when students actively build their knowledge through hands-on experience. which is evident in experiments using Solar Sprinkle and Ecoburn that facilitate students to apply the concepts learned in real-life situations. Vygotsky also supports this through the Proximal Development Zone (ZPD). which shows that students can develop more optimally through mentorship and collaboration. which is reflected in the use of technology-based learning media that allows interaction and discussion (Boye & Agyei, 2023; Harland et al., 2021; Lestari et al., 2022; Lumadi & Len, 2013).

In addition. the experiential learning theory proposed by John Dewey is also relevant to these results. Dewey argues that students learn best when they engage directly in activities that are relevant to their lives. The use of experiments in STEM-based learning provides an opportunity for students to experience first-hand application of theory in real-world contexts which helps them understand concepts more deeply (Aisyah et al., 2023; Sukmawati et al.. 2023; Sukmawati et al., 2022a).

However. not all students show the same big change. For example. S5 students who still get a score of 0 on the pretest and posttest. indicating that there are other factors influencing. such as lack of involvement in learning. This could be related to the Self-Determination Theory (SDT). which reveals that students' motivation will increase if they feel they have control over their learning. Thus. students who are less motivated or not actively involved in the experiment may not show significant changes (Celik, 2023; Raes et al., 2020; Alten et al., 2019).

The results of this study show that STEM-based learning that integrates interactive media such as Solar Sprinkle and Ecoburn is effective in improving students' science literacy skills. with more significant changes recorded in students with lower initial understanding. in accordance with the theoretical principles of

constructivism. experiential learning. and motivation in learning (Aisyah et al., 2023; Ifdaniyah & Sukmawati, 2024).

Table 2. Changes in environmental awareness abilities

Respond	Measure the Environmental Awareness		
	Pretest	Post-tests	Change
S1	-0.41	0.41	0.82
S2	-0.86	0	0.86
S3	0	0.86	0.86
S4	0	2.22	2.22
S5	0.86	2.22	1.36
S6	-0.41	1.4	1.81
S7	-0.41	1.4	1.81
S8	0.41	1.4	0.99
S9	-0.41	0.86	1.27
S10	0	1.4	1.4
S11	-0.86	0.86	1.72
S12	0.41	1.4	0.99
S13	0	1.4	1.4
S14	0	1.4	1.4
S15	-0.41	1.4	1.81
S16	-0.86	0.86	1.72
S17	-0.86	0.86	1.72
S18	0.41	1.4	0.99
S19	-0.86	0.41	1.27
S20	-0.86	0.41	1.27
S21	0.41	1.4	0.99
S22	0	1.4	1.4
S23	0.86	2.22	1.36
S24	-0.41	1.4	1.81
S25	0	1.4	1.4
S26	-0.41	1.4	1.81
S27	0	1.4	1.4
S28	0.86	2.22	1.36
S29	0	1.4	1.4
S30	-0.41	0.41	0.82
S31	0	1.4	1.4
S32	0	0.86	0.86
S33	0	1.4	1.4
S34	-0.41	1.4	1.81
S35	0.41	1.4	0.99
S36	0.86	1.4	0.54
S37	0	0.86	0.86
S38	-0.86	0.86	1.72
S39	0.86	2.22	1.36
S40	0.86	1.4	0.54
S41	-0.41	0.86	1.27
S42	0.41	0.86	0.45
S43	-2.22	0.41	2.63
S44	-0.41	0.86	1.27
S45	0.41	1.4	0.99
S46	0.41	1.4	0.99
S47	-1.4	0.41	1.81
S48	-1.4	0.41	1.81
S49	-0.86	0.41	1.27
S50	-0.41	1.4	1.81

Discussion

Based on the data provided regarding changes in the environmental awareness ability of students who participated in science learning with the theme of renewable energy and the environment. there was a significant variation in the results of the students' pretest and posttest. This learning process involved 50 respondents who did a pretest and posttest to measure their increased awareness of environmental issues that had been taught through STEM-based learning (Karaçor & Akçam, 2023; Dewi et al., 2024; Tabuenca et al., 2023).

On the pretest. most students show low or even negative scores. indicating a limited understanding of environmental issues before participating in STEM-based learning. However. after being given the treatment of learning based on interactive media such as Solar Sprinkle and Ecoburn. the posttest results showed a significant improvement. For example. students with S1 ID who obtained a score of -0.41 on the pretest. achieved a score of 0.41 on the posttest. showing an increase of 0.82. Larger improvements were also seen in other students. such as S43. which showed a remarkable change from -2.22 on the pretest to 0.41 on the posttest. with an increase of 2.63. In general. most students who had negative pretest scores showed significant improvements. indicating that STEM-based learning had a positive effect on improving students' environmental awareness (Khoiri et al., 2021; Li, 2024; Oe et al., 2022).

However. some students did not show the same significant improvement. Students such as S30 who have a fixed pretest and posttest score of 0 indicate that there are other factors that affect learning outcomes. such as lack of involvement in the learning process or difficulty in understanding the material (Oliver & Adkins, 2020; Wijayanto et al., 2024). This shows that although most students experience improvement. individual factors still play an important role in learning outcomes.

This increase in environmental awareness can be explained through the Constructivist Theory of Piaget and Vygotsky. Piaget states that students build their own knowledge through hands-on experience. In STEM-based learning. students not only listen to theory but also participate directly in experiments that help them conceptualize their knowledge in a more in-depth way (Abed et al., 2024; Tadena & Salic-Hairulla, 2021). Vygotsky's Proximal Development Zone (ZPD) is also relevant. as STEM-based learning allows teachers to play the role of facilitators who help students through social interactions. supporting them to achieve deeper understanding.

Conclusion

Based on the results of research on students who participated in science learning with the theme of

renewable energy and the environment using STEM-based media, there was a significant increase in science literacy and environmental awareness. Most students showed clear improvements, such as student S1, who increased their score from -0.41 on the pretest to 0.41 on the posttest (an increase of 0.82), and student S43, who increased from -2.22 to 0.41 (an increase of 2.63). This improvement reflects a better understanding of renewable energy and its impact on the environment. Although most students experienced improvement, some students, such as S30, did not show significant changes, indicating that individual factors, such as engagement in learning, affect the results. Overall, STEM-based learning has proven to be effective in improving science literacy, which is directly linked to improving students' environmental awareness. Good science literacy allows students to understand natural phenomena and the impact of human activities on the environment, as well as make evidence-based decisions that support nature conservation. Through STEM-based learning, students not only learn theory but also engage in experiments that deepen their understanding of environmental issues, such as the use of renewable energy. Thus, STEM-based learning helps develop higher environmental awareness, encouraging students to act more responsibly towards the environment. Individual involvement and motivation remain key factors in the success of this learning.

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The authors declare no conflict of interest.

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