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Pre-service teachers' responses to the use of a solar-powered science kit in elementary science learning

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Abstract: *Solar powered science kit is a learning media that is considered capable of helping students understand the concept of renewable energy through direct experience and simple experiments. This study aims to describe students' responses to the use of Solar Powered Science Kit as a learning media in elementary schools. The research method uses a qualitative descriptive approach. The results of the study show that students gave positive responses to the media, including increased learning motivation, ease of understanding energy concepts, student activeness in practical activities, and the emergence of critical attitudes towards environmental issues and alternative energy. Based on the results of the study, it can be concluded that students have a good response to the use of Powered Science Kit media in learning and assess this media according to the characteristics of students in elementary schools.*

Keywords: *students' responses; learning media; solar powered science kit; science education; renewable energy*

Introduction

In higher education, science learning in Primary School Teacher Education programs requires pre-service teachers to develop solid conceptual understanding, practical skills, and pedagogical approaches that are relevant for managing science instruction in elementary schools (Dewi, 2019; Muhamad Alfarisi, Andi Widiono, 2025). Therefore, appropriate pedagogical approaches are required to effectively manage science instruction in elementary schools (Alhamid & Nisa, 2024). Therefore, students need to be introduced to a variety of innovative and contextually relevant learning media. Such media play a crucial role as tools that bridge abstract concepts and make them more concrete and easier to understand (Arsyad, 2022; Yusra et al., 2025)

The Elementary Learning Media course is one of the compulsory courses in the PGSD curriculum. In this course, students are not only expected to master theoretical foundations but are also required to analyze, design, and practice the use of instructional media in classroom settings. In this context, the use of a solar powered science kit provides pre-service teachers with opportunities to explore the concept of renewable energy through simple experimental activities. The kit typically consists of a small solar panel, a mini electric motor, a fan, LEDs, and other components that can be assembled into simple demonstration tools powered by solar energy.

The use of concrete media is particularly important in science learning because it provides students with direct, hands-on experiences (Siregar & Tarigan, 2022; Anggraini & Mulyani, 2025; Setyaningsih et al., 2019). According to the Cone of Experience, learning activities are most effective when they involve direct and manipulative experiences(Adiansi

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et al., 2025; Agustian, 2018; Darman, 2020; Fitri et al., 2024) . Pre-service elementary teachers need to experience this kind of concrete engagement so that they are able to design and implement meaningful science lessons when they teach at the primary level.

Furthermore, science learning that emphasizes renewable energy literacy is highly relevant to current global issues. Students need to understand the challenges of the energy crisis and the importance of transitioning to alternative energy sources. Through the solar powered science kit, they can directly observe how solar panels work and explore their potential applications in everyday life. Such experiences contribute to the development of energy literacy and raise students' awareness of sustainability issues.

The use of innovative media such as a solar kit also has implications for learning motivation. Ramli et al. (2018) and Yusnaldi et al. (2025), argue that learning media can enhance students' interest, attention, and engagement. Therefore, understanding how students respond to the use of a solar kit is essential as a basis for evaluating the effectiveness of the medium and for developing more optimal science learning strategies in higher education.

Based on the results of previous research which have emphasized the importance of using concrete media in science learning, most studies still focus on the use of general laboratory media, simple demonstration tools, or conventional science kits, and not many have specifically examined the effectiveness of concrete media in science learning.Solar Powered Science Kitas a tool for understanding renewable energy concepts in the context of elementary school teacher education. Research by Handayani (2018) emphasized the role of laboratory experiences in improving understanding of scientific concepts, but did not examine solar energy media as a concrete learning tool. Similarly, a study by Estuhono, Anggrayni (2025) showed the use of natural props (alarms, lights, and solar panel fans) to foster scientific literacy, but the study was conducted on elementary school students, not on prospective teacher students. In addition, research by Naimah (2022) on concrete media in the surrounding environment that are used as simple tool kits to improve competence and creativity, but this study only highlighted the use of traditional science props without examining how to adapt renewable energy media for elementary school learning. Thus, there is not much research that directly explores howSolar Powered Science Kitcan improve the conceptual understanding of PGSD students while building their pedagogical competence in designing and implementing renewable energy-based science learning. This gap is the basis for the urgency of this research, because students' understanding as prospective teachers of concrete media based on renewable energy is an important factor in supporting a modern science curriculum that emphasizes energy literacy, sustainability issues, and real-life experiential learning. By filling this gap, this research provides a new contribution to the study of science learning media, especially in the context of student responses to the implementation of renewable energy in science learning.

Method

This study employed a descriptive qualitative design aimed at providing an in-depth portrayal of students' responses to the use of a solar powered science kit in science learning. A qualitative approach was chosen because it enables the exploration of students' learning experiences, perceptions, and views in a natural context. The sampling technique used in this study was purposive sampling. The subjects were elementary school teacher education (PGSD) students taking the Elementary School Learning Media course at STKIP Kusuma Negara in the 2025/2026 academic year. Data were collected using three main techniques: (1) classroom and practicum observations conducted while students used the solar kit; (2) open-ended questionnaires containing questions about their experiences, difficulties, and perceived benefits of using the media; and (3) short interviews with selected students to enrich and validate the questionnaire data. The combination of these three techniques was intended to obtain rich, complementary data.

Data analysis followed the Miles and Huberman model, which consists of three interconnected stages: data reduction, data display, and conclusion drawing. Data reduction is the initial stage of analysis and involves selecting, focusing, simplifying, and organizing raw data collected during the study, as well as eliminating information that is not relevant to the research focus (Qomaruddin, 2024). Facilitate subsequent retrieval and analysis. Data reduction thus serves as a process of simplifying and transforming data into a more structured form. The next stage, data display, involves organizing the reduced data into formats that allow the researcher to identify patterns, relationships among categories, and an overall picture of the findings. The final stage, conclusion drawing, consists of interpreting the organized data to formulate meanings and derive key findings from the analysis (Qomaruddin, 2024).

Results and Discussion

Students' Responses to Learning Experiences Using the Solar Kit

The analysis of questionnaire and interview data shows that students responded positively to the use of the solar powered science kit. Most students reported that the medium provided them with a new and meaningful learning experience. They felt that it was easier to understand the concept of renewable energy because they could directly observe the relationship between sunlight, the solar panel, and the resulting energy transformation. Students' responses to the use of the solar powered science kit are summarized in Table 1.

The data shows that 56% of students responded very positively, meaning more than half of the students felt the solar-powered science kit was a highly effective learning tool, engaging, easy-to-understand, and able to explain renewable energy concepts simply. This response reflects the students' high enthusiasm, active engagement, and intrinsic motivation. These findings align withan Arsyad (2022), who argues that concrete instructional media significantly enhance learners' attention, motivation, and engagement because they offer experiences that are more authentic and meaningful. These findings are consistent with Pane et al. (2022) who found that practical demonstration tools can enhance learners' interest and academic outcomes.

Table 1. Students' Responses to the Solar Powered Science Kit

Category	Percentage	Indicator
Very positive	56%	Highly enthusiastic, actively trying out experiments, eager to use it in future SD teaching
Positive	35%	Perceive the medium as engaging, easy to understand, and helpful for grasping concepts
Fair	6%	Like the medium but experience technical obstacles
Low	3%	Experience difficulties in understanding electrical circuits and light intensity

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Students in the fair category (6%) noted that although the medium was beneficial, they encountered several technical challenges, such as the sensitivity of the solar panel to light intensity and difficulties arranging the electrical components. These findings correspond with those of Lestari et al. (2025) and Morrison & Sebens (2016), who reported that solar-based experimental media require optimal light intensity to function properly. Despite these challenges, students remained positive about the learning value of the media.

The low category (3%) represents a small portion of students who experienced significant difficulties understanding electrical circuits and changes in light intensity. This is reasonable given that not all PGSD students have strong backgrounds in electrical components. Alfarisi et al. (2025) similarly found that pre-service elementary teachers often struggle with electronic components during basic science practicums because they are more accustomed to theoretical explanations than technical practices.

From the perspective of Piaget's cognitive development theory, the predominance of positive responses suggests that students learn more effectively when engaged in hands-on activities. Piaget emphasized that learning becomes more meaningful when learners manipulate concrete objects to construct an understanding of abstract concepts. The solar kit fulfills this function by enabling students to directly observe the relationship between sunlight and electrical energy, thereby strengthening their conceptual understanding of renewable energy (Khanafi et al., 2025).

The kit functions not only as a practical tool but also as a stimulus for scientific process skills such as observing, questioning, experimenting, and drawing conclusions. These findings reinforce Harlen (2015) assertion that experiment-based learning promotes scientific reasoning and curiosity. The high number of very positive responses indicates that the solar kit successfully fosters scientific thinking through simple yet meaningful experiments.

Affective responses also emerged strongly. Students reported that the solar kit made science learning more enjoyable, colorful, and far from monotonous. This supports Edgar Dale's Cone of Experience, which posits that direct experiences with real objects enhance emotional engagement and deepen understanding compared to listening or reading alone (Dash, 2023). Students' positive responses demonstrate that concrete media can meaningfully elevate the affective dimension of learning.

Contextually, the solar kit enabled students to better understand global issues related to renewable energy. Amelliyah et al. (2025) found that solar-based learning media improve learners' environmental awareness and energy literacy. Students' strong responses in this study show that they not only grasp the concepts but are also motivated to integrate renewable energy innovations into future teaching.

These positive responses have important implications for elementary science instruction. As pre-service teachers, students recognized the potential of this medium for teaching science in primary schools.Aryani et al. (2024) argue that PGSD students who gain hands-on experience with concrete media demonstrate higher confidence and competence in teaching science. Thus, strong student responses indicate readiness to adopt similar media in future instruction.

Overall, the interpretation of the data shows that the solar powered science kit is highly effective in enhancing understanding, motivation, and interest in renewable energy concepts. The high proportion of positive responses (90%) affirms the superiority of concrete media compared to lecture-based or passive visual instruction. Supported by theory and previous research, solar-based experimental kits represent a relevant and innovative learning alternative that enriches students' learning experiences and prepares them as competent future educators.

The quotations provided by the students offer strong evidence of how the solar powered science kit directly influenced their learning processes. Student M1 stated, "I finally understood how a solar panel works after trying it myself. It turns out that renewable energy concepts can be explained very simply like this". This illustrates the cognitive impact of the medium, showing that concrete media effectively enhance conceptual understanding. Students not only grasped theoretical explanations but also developed a more complete conceptual understanding through hands-on experience. This finding aligns with Piaget's theory of the concrete-operational stage, which posits that scientific concepts are better understood when learners directly manipulate real objects. It is also supported by Sutinah (2022), who emphasize that laboratory experiences significantly improve conceptual learning.

Student M7 stated, "The learning was not boring. It felt like playing, but we were actually learning science." This quotation highlights the affective dimension of learning, reflecting increased enjoyment and motivation when concrete media are used. Science learning is often perceived as abstract and monotonous when delivered through lectures alone. However, direct experimentation with the solar panel and observing visible energy transformations make learning more enjoyable. This aligns with Dash (2023), who stresses that direct, concrete experiences generate emotional engagement and improve learning effectiveness, a finding also echoed by (Aryadillah et al., 2018).

Student M12 noted, *“Elementary school children would be even more excited. The fan can move, and the LED lights up—it makes the concept very real.”* This shows the pedagogical awareness that students developed, as they were not only reflecting on their own learning but also evaluating the tool’s suitability for future teaching. This indicates growth in pedagogical reasoning, particularly in judging the appropriateness of learning media for younger learners. Komala (2025) supports this finding, showing that concrete media experiences strengthen pre-service teachers’ ability to design and implement relevant science instruction for elementary students.

Student M25 commented, *“The only challenge is cloudy weather—the panel doesn’t work optimally. But it’s still very interesting to explore.”* This reflects the technical difficulties encountered, especially the dependence on light intensity. Students recognized the limitations but also appreciated the learning value because the challenge revealed an authentic characteristic of solar energy systems. Morrison & Sebens (2016) similarly found that solar-based media often face issues related to light variability, but these challenges provide added educational value about the nature of renewable energy.

Student M30 added, “Media like this should be available in schools. It really helps explain alternative energy.” This reinforces the relevance of the solar kit in contemporary science education. Students recognized the importance of introducing renewable energy at an early age as part of environmental education. These insights align with Setiawan & Suhandi (2020), who reported that solar-energy demonstration tools improve learners’ understanding of sustainability issues and alternative energy.

Collectively, these five quotations show that the solar kit positively influenced the cognitive, affective, motivational, and pedagogical aspects of students’ learning. Cognitively, the medium helped students understand solar panel mechanisms and energy conversion pathways. Affectively, students enjoyed the learning experience and found it far from monotonous. Motivationally, they demonstrated enthusiasm in conducting various experiments. Pedagogically, they acknowledged the suitability of the tool for elementary science classes.

Furthermore, the quotations illustrate how concrete media serve as a bridge between theory and practice. Students were not merely recalling the definition of renewable energy; they were able to see, feel, and manipulate the device representing the concept. This is critical in science learning because, as Fuadi et al. (2020) argue, strong conceptual understanding arises when learners directly experience the phenomena being studied.

The quotations also indicate that students engaged in inquiry based learning, as they experimented with and tested components of the media. These activities are aligned with scientific inquiry principles observing, questioning, experimenting, and concluding suggesting that the medium not only teaches renewable energy concepts but also develops scientific skills. Sarudin et al (2024) states that active learning provides a deeper understanding and is able to apply the concepts learned more effectively.

Taken together, the student quotations provide strong empirical evidence that the solar powered science kit is highly effective for enhancing the quality of science learning. The medium not only strengthens understanding of renewable energy concepts but also creates enjoyable learning experiences, boosts motivation, enriches scientific process skills, and prepares pre-service teachers to design effective science instruction for elementary school students.

Media Supporting Students' Understanding of Renewable Energy Concepts

Students reported that the solar kit helped them better understand several key concepts, including light energy, electrical energy, energy conversion, and the use of alternative energy sources. This is consistent with Piaget's theory, which emphasizes that concrete experiences significantly enhance conceptual understanding. Several indicators of improved understanding were identified: (1) comprehension of the relationship between light energy and electrical energy, (2) understanding of light intensity, (3) understanding of energy efficiency, and (4) the ability to contextualize learning with environmental issues (Ristiani et al., 2025).

The use of the solar powered science kit proved effective in helping students grasp renewable energy concepts more concretely and comprehensively. Students stated that the medium bridged the gap between abstract ideas such as light energy, electricity, energy conversion, and alternative energy use and real, observable experiences. This finding aligns with Anggraini et al. (2025) who emphasize that learners construct knowledge through concrete engagement. In this context, students did not merely read or listen to explanations about renewable energy; instead, they directly experienced how sunlight can be converted into electricity to power a mini fan or light up an LED. Manipulating the tool, observing outcomes, and drawing their own conclusions resulted in stronger conceptual understanding than lecture-based or purely visual instruction.

The first indicator of improvement was students' understanding of the relationship between light energy and electrical energy. Through direct experimentation, students observed how sunlight directed at the solar panel generated electricity that powered a motor or mini fan. This cause–effect relationship helped solidify their understanding of energy conversion, which they may have previously comprehended only at a theoretical level. Mulia, & Murni (2022) similarly found that laboratory experiences enhance concept retention and increase learners' ability to explain scientific phenomena accurately.

Students also demonstrated improved understanding of light intensity. They independently modified the position and angle of the solar panel and observed how the brightness of the LED changed in response to the light received. This exploratory activity helped students recognize that the electrical output of a solar panel depends greatly on the amount of light absorbed. These findings are consistent Lukma et al. (2023) who showed that solar-energy experimental models help learners understand the links between light intensity, energy conversion, and electrical output through empirical observation.

Students' understanding of energy efficiency also increased. They concluded that greater light intensity results in greater electrical output, and they learned how environmental conditions and panel orientation influence solar-panel performance. This knowledge is important because it reflects real-world challenges of renewable energy systems. Entang et al. (2024) likewise found that miniature renewable-energy devices effectively convey technical limitations and principles of energy efficiency to learners.

Another emerging aspect was students' ability to contextualize their learning within national and global energy issues. Many began to relate their small-scale experiments to Indonesia's solar-energy potential, global warming, and the need for clean energy transitions. This suggests that concrete media foster not only conceptual understanding but also ecological awareness and sustainability-oriented thinking. Parisu et al. (2025) argue that effective science education does not merely teach concepts; it also enhances scientific literacy and environmental concern. Thus, the solar kit functions as a bridge between classroom science and real-world environmental contexts.

Student M4's statement, "I realized that solar energy is very promising, because even a small experiment can generate electricity," reflects a shift in perspective resulting from direct experiential learning. This quotation indicates that the medium supports not only academic understanding but also practical awareness of renewable energy's potential in everyday life. Affectively, it demonstrates a growing sense of relevance, as students recognize that what they learn is meaningful and applicable. This aligns with Herdiani & Susilawati, (2025) who found that active learning increases perceived relevance and real-world connectedness.

Overall, the data and student quotations show that the solar powered science kit makes a significant contribution to improving the quality of learning about renewable energy concepts. Direct engagement in observing physical phenomena, manipulating variables, and drawing independent conclusions makes learning more meaningful, rich, and deep. This concrete medium not only enhances conceptual understanding but also fosters scientific process skills, learning motivation, and ecological awareness a combination of outcomes essential for modern science education. Thus, the solar powered science kit can be concluded to be a highly effective and relevant instructional strategy for pre-service elementary teachers and for implementation in elementary classrooms.

Increased Student Motivation and Engagement

Observational data indicate that students became more actively involved in discussions, experimenting with circuit connections, and attaching the solar panel to various experimental components. Many students attempted different variations of the experiments, such as exposing the solar panel to different light intensities, adjusting its angle, and testing additional components. This high level of engagement aligns with Melati et al. (2023), who state that instructional media can enhance learners' motivation and participation. Students' activities during the practicum are summarized in Table 2.

The data in Table 2 show that the solar powered science kit effectively facilitated students' learning activities, with very high levels of involvement across almost all activity indicators. The highest percentages were found in observing how the solar panel works (94%) and engaging in discussion and asking questions (92%), indicating that the medium successfully stimulated students' curiosity and supported intense social interaction during learning. Observation is a fundamental component of science learning; as (Harlen, 2015) notes, observational skills are a basic scientific capability that underpins the development of scientific thinking. The high proportion of students engaged in observation suggests that concrete media such as the solar powered science kit are effective in capturing students' attention and guiding them to observe the process of energy conversion directly, making learning more meaningful and grounded in real phenomena.

Table 2. Students' Activities During the Practicum

Activity	Percentage of Students Involved
Observing how the solar panel works	94%
Assembling wires and kit components	81%
Conducting experiments with varying light intensity	76%
Recording results and drawing conclusions	87%
Engaging in discussion and asking questions	92%

The high percentage of students involved in discussion and questioning (92%) also indicates that learning with the solar kit promotes social interaction and active knowledge exchange among students. This activity is a key indicator within Vygotsky's social constructivist perspective, which emphasizes that knowledge is constructed through social interaction, collaboration, and negotiation of meaning. The discussions that took place during the practicum suggest that students were not only constructing understanding individually, but also verifying and extending their understanding through argumentation, group discussion, and questions arising from their observations. Such learning conditions are consistent with the findings of Putri, Hidayah, & Gusmaneli, (2025), who reported that discussion-based active learning improves conceptual understanding, critical thinking, and knowledge retention.

The activity of recording results and drawing conclusions (87%) further demonstrates that students were not merely conducting experiments but were also engaged in higher-level scientific processes such as data analysis and inference. In science education, recording, processing information, and making interpretations are key indicators of higher-order thinking skills. Students' involvement in these activities indicates that the use of concrete media not only encourages motor and observational engagement but also develops scientific skills such as reasoning, inference, and analysis. This aligns with inquiry-based learning theory, which stresses the importance of reflection after experimentation to consolidate conceptual understanding (Praherdhiono & Untari, 2025).

The activity assembling wires and kit components (81%) indicates that most students participated in psychomotor tasks requiring hand–eye coordination, precision, and an understanding of circuit structure. This type of activity is crucial in science learning because it involves procedural skills in conducting experiments. The relatively high percentage suggests that students had the confidence and willingness to assemble components independently, even though some may have struggled with technical aspects. This finding supports Chusna & Chisbiyah, (2024), who argue that direct experience in assembling electrical components enhances practicum skills and understanding of basic physics concepts.

Meanwhile, the activity of conducting experiments with varying light intensity (76%) shows that a large proportion of students took the initiative to explore beyond the basic instructions. This exploratory behavior reflects the nature of scientific inquiry, as students modified variables such as panel angle, distance from the light source, and light intensity to examine how these factors affect energy output. Such activities support the findings of Fadhilah et al. (2023), who reported that exploratory work with solar energy kits improves investigative skills and understanding of variable relationships in energy concepts.

Taken together, the high activity levels demonstrate that concrete media such as the solar powered science kit can simultaneously promote cognitive, social, affective, and psychomotor engagement something that is difficult to achieve in lecture based instruction. The solar kit functions as a learning trigger that not only captures students' attention but also facilitates social interaction, stimulates curiosity, and encourages independent experimentation (Al-Thani & Ahmad, 2025; Ostroff, 2016). In this way, the medium creates a learning environment that is collaborative, inquiry-oriented, and student centered.

Moreover, the consistently high percentages across nearly all activity indicators show that learning with concrete media fosters active and constructive learning, in which students become the main agents in constructing their own knowledge. Activities such as observing, discussing, experimenting, and drawing conclusions correspond to stages of the scientific method that are naturally integrated into the practicum. Such learning processes have been shown to enhance conceptual understanding, analytical skills, and scientific competencies, as supported by inquiry-based science education research.

In conclusion, the solar powered science kit significantly increased students' engagement across all aspects of the learning process. The high levels of observation and discussion indicate that the medium is effective in stimulating active learning and social interaction. Activities involving assembling components, conducting experiments with varying light intensity, and recording and concluding results show that the medium also strengthens scientific process skills and higher-order thinking. Overall, the high levels of student activity reinforce the effectiveness of the solar powered science kit as a science learning medium that creates rich, meaningful, and practice-based learning experiences.

Challenges and Constraints of Using Solar Kits

Qualitative findings indicate that the solar powered science kit offers four major strengths that significantly contribute to the effectiveness of science learning. The first strength lies in its ability to transform abstract concepts into concrete ones. Renewable energy, energy conversion, and light intensity are often difficult to understand through verbal explanation or illustration alone. However, with this concrete medium, students can directly observe how sunlight powers a mini fan, lights up an LED, or drives a small motor. Such empirical experiences support the development of new cognitive schemas. Piaget's theory reinforces this idea, asserting that learners understand complex concepts more effectively when they can physically manipulate real objects and observable phenomena. Thus, the solar kit functions as an effective conceptual bridge, linking theory to direct experience.

The second strength is that the medium makes learning more interesting and enjoyable. Students reported that learning with the solar kit created a much more dynamic learning atmosphere compared to conventional instruction. Experimental activities involving the movement of the fan, the glow of the LED, and the interaction with sunlight created visual, kinetic, and emotional learning experiences. This enjoyable learning experience aligns with Dale's Cone of Experience, which emphasizes that direct experiences are the most engaging and lead to stronger long-term memory formation. Melati et al. (2023) also note that enjoyable learning enhances intrinsic motivation, sustains focus, and promotes active engagement. This emotional involvement enables students to remain engaged longer and exhibit high levels of enthusiasm during the practicum.

The third strength is that the medium fosters curiosity and scientific attitudes. During the practicum, students actively varied the position of the solar panel, observed the kit's responses to changes in light intensity, and posed critical questions about the differing experimental results. This indicates that the kit naturally stimulates scientific inquiry. The curiosity that emerges encourages students to form hypotheses, conduct additional trials, and engage in group discussions. Harlen (2015) argues that scientific attitudes such as curiosity, perseverance, and the ability to ask questions are fundamental prerequisites for high-quality science learning. Therefore, the solar kit functions not only as a demonstration tool but also as a medium for cultivating foundational scientific dispositions.

The fourth strength is the ease with which the medium can be implemented in elementary school learning. PGSD students acknowledged that the kit's simple, safe, and appealing design is well-suited to the characteristics of elementary students, who are in the concrete operational stage. The solar kit offers authentic experiences that help young learners understand renewable energy concepts in a non-monotonous way. Furthermore, the medium supports constructivist learning approaches, where students actively construct understanding through exploratory, collaborative, and investigative activities. Khanafi et al. (2025) affirm that concrete media such as solar energy kits greatly enhance elementary students' understanding because they present scientific phenomena in observable and tangible forms. Thus, the medium has high potential for implementation in elementary science classrooms.

Taken together, these four strengths highlight that the solar powered science kit effectively "brings science learning to life." This phrase refers to the medium's ability to make abstract concepts touchable, visible, and directly experienced, resulting in learning that is active, enjoyable, meaningful, and effective. According to multimodal learning theory, such multisensory experiences enhance memory and deepen understanding.

Despite these strengths, the study also identified several technical constraints. The first challenge is its dependence on sunlight intensity. On cloudy days or when sunlight is unstable, the performance of the solar panel declines, reducing the effectiveness of the experiment. This limitation is inherent to solar technology; as Rosadi & Hadi, (2020) explain, solar panel output depends heavily on light intensity and the angle of exposure. However, this constraint also provides valuable opportunities for scientific discussion about environmental factors affecting renewable energy.

The second constraint is that small kit components are easily detached. Items such as small wires, mini motors, or clips often require reassembly. This can slow down practicum activities and demands extra precision from students. Such challenges are more pronounced among students who are less familiar with electronics-based practicum activities. Nevertheless, this issue can be addressed through clearer instructions or closer supervision from lecturers.

The third constraint is that some students struggled to connect the wires. This difficulty typically occurred among students with limited prior experience or knowledge of electrical circuits. However, this challenge is technical rather than conceptual. For some students, the difficulty became a valuable learning moment because it introduced them to basic electrical knowledge relevant for elementary science instruction.

Although several technical challenges were identified, they did not diminish the overall educational value of the medium. These constraints are operational in nature and can be managed with better preparation or clearer technical guidance. Meanwhile, the positive impacts on students' understanding, motivation, scientific process skills, and pedagogical readiness far outweigh the challenges. Thus, the solar powered science kit remains a highly effective, relevant, and promising instructional medium for integration into science learning at both the university level and in elementary schools.

Implications for Elementary Science Education

The findings of this study show that students consider the solar powered science kit to be highly relevant and appropriate for use in elementary science instruction, particularly in topics related to energy and alternative energy sources. Students concluded that this medium is not only safe and easy to use but also effective in providing authentic learning experiences through activities such as observing, experimenting, modifying components, and directly witnessing the conversion of sunlight into electrical energy. This response reflects students' understanding that science learning at the elementary level must be concrete, contextual, and aligned with the cognitive characteristics of elementary-aged learners, who are still in the concrete operational stage according to Piaget's theory. By enabling students to encounter real, observable phenomena, the solar kit helps young learners grasp abstract concepts of renewable energy through direct sensory experience.

The relevance of this medium for elementary instruction is also evident in its simple, safe, and visually appealing physical design. Components such as the mini fan, LED light, and small solar-powered car produce engaging visual effects that naturally capture children's attention and curiosity. This aligns with Dale's theory emphasizing the importance of direct experience in building understanding and long-term memory (Dash, 2023). Thus, the solar kit functions not only as an instructional aid but also as a tool for enhancing focus, motivation, and engagement in science learning. PGSD students recognized that this hands-on medium helps bridge the gap between abstract concepts such as energy conversion and alternative energy sources and the real-world experiences of children.

Furthermore, the use of the solar kit contributes positively to the development of students' pedagogical competencies as pre-service teachers. Throughout the practicum, students gained firsthand experience in designing simple experiments, identifying variables, and evaluating experimental outcomes. These skills are central to pedagogical competence in science education, which emphasizes inquiry-based approaches and scientific process skills. In line with Harlen (2015), competent science teachers must be able to design learning experiences that allow students to observe, question, collect data, and draw conclusions. Students' practice with the solar kit reinforces these abilities, better preparing them to design creative and effective science lessons for elementary classrooms.

In addition to experimental design skills, students demonstrated improved understanding of how renewable energy systems work. This is essential because elementary teachers must not only deliver content but also possess a strong conceptual grasp in order to simplify scientific ideas and communicate them clearly to learners. Through hands-on experience with the solar kit, students developed an understanding of energy conversion, light intensity, and solar panel efficiency within authentic experimental contexts. Such knowledge enables them to craft clearer, more relatable explanations for elementary students. Penelitian Sagitarini et al., (2020) found that teachers with experience using concrete teaching media are better able to explain scientific concepts in simple and meaningful ways, thereby enhancing elementary students' comprehension.

Using the solar kit also trained students to simplify complex scientific concepts into concrete, accessible learning experiences—a key aspect of pedagogical content knowledge (PCK). Students learned to break down broad concepts such as renewable energy into manageable activities, such as lighting an LED with sunlight, powering a mini fan, or adjusting the panel's angle to identify optimal light intensity. This aligns with Siprianus, Durasa, & Fil, (2024) who argue that effective teachers understand both the content and how to adapt it to students' comprehension levels. Thus, the experience of working with the solar kit contributes significantly to the development of students' PCK.

Students' overall conclusion that the solar kit is highly suitable for elementary science teaching also demonstrates their reflective abilities as future educators. They evaluated the medium not only from their own perspective but also through the lens of young learners. Their recognition that the medium is safe, engaging, and capable of stimulating curiosity indicates a deep understanding of elementary students' needs and characteristics. Research by (Khanafi et al., 2025) similarly supports the use of simple solar energy kits in primary education, noting that they introduce scientific phenomena in enjoyable and easily implemented ways.

In summary, the solar powered science kit offers dual benefits: it enhances university students' learning while simultaneously strengthening their pedagogical and professional competencies as future teachers. The medium deepens their understanding of science concepts, trains them to design simple experiments, sharpens their ability to simplify complex ideas, and reinforces their pedagogical intuition in selecting appropriate instructional media for elementary learners. Overall, the solar kit serves as a two-way learning tool teaching students about renewable energy while equipping them to teach the same concepts to children in effective, concrete, and engaging ways.

Conclusion

This study shows that the Solar Powered Science Kit effectively enhances students' understanding of renewable energy concepts, strengthens their learning motivation, and develops their pedagogical competence as future teachers through engaging and enjoyable concrete learning experiences. The novelty of this study lies in its focus on PGSD students as future educators, filling a gap in previous research that generally only examined the use of concrete media with elementary school students. Thus, it provides a new scientific contribution regarding the role of solar kits in preparing future teachers who are able to simplify scientific concepts and design renewable energy-based experiments. However, this study has limitations such as the device's dependence on sunlight intensity, potential technical problems with small components, and a limited number of participants, so the results cannot be generalized widely. Therefore, further research is recommended to involve more diverse participants, use mixed-methods or quasi-experiments to test the media's influence more robustly, and develop other renewable energy media and supporting learning tools to optimize its implementation in elementary schools.

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