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Analyzing Project Outcomes and Students' Responses of Renewable Energy STEAM Kit

Lintang Rahmayanti[1], Sentot Budi Rahardjo[2]*, Sukarmin[3]

[1]Science Education, Universitas Sebelas Maret, Surakarta, Indonesia.
[2]Chemistry, Universitas Sebelas Maret, Surakarta, Indonesia.
[3]Physics Education, Universitas Sebelas Maret, Surakarta, Indonesia.

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Corresponding Author:
Sentot Budi Rahardjo
sentotbr@staff.uns.ac.id

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Abstract: Addressing global challenges requires a strong focus on environmental sustainability within educational institutions. This research aims to analyze the project outcome and student's responses of Renewable Energy STEAM Kit. The study involved 31 students who participated in the learning project using Renewable Energy STEAM Kit. Data was collected through observation to assess the project outcome of learning activities, and survey & interview to gather student's responses about their experiences from learning activities using Renewable Energy STEAM Kit. Data processing utilized descriptive quantitative methodologies to derive significant insights from the provided data. According to the result, 96.8% of students agreed and strongly agreed that the Renewable Energy STEAM Kit is easy to use, interest, flexible, benefit, and relevant. Only 3.2% of students that disagreed about that statement. The results of this study can be concluded that Renewable Energy STEAM Kit's success in being user-friendly, engaging, flexible, beneficial, and relevant to students' educational experiences and future aspirations.

Keywords: Project outcome; Renewable energy; Science Kit; STEAM

Introduction

In the face of growing environmental concerns and the urgent need for sustainable solutions, educating students about renewable energy has become more critical than ever. Significant amounts of greenhouse gases, such as methane, carbon dioxide, and nitrous oxide are expected to rise over time due to the rapid rate of civil and industrial growth (Olabi & Abdelkareem, 2022). In this context, science education holds an important role in our everyday lives. Çoker et al. (2010) states that teachers need to contextualizing energy concepts in school curricula, while also contributing to increasing awareness about environmental issues.

Science education should educate students about addressing global challenges and empowering them to contribute to solutions (Kyle, 2020). Climate change is one of the most urgent issues confronting the international community (Han & Ahn, 2020). Utilizing renewable energy sources is a key strategy for reducing the impacts of climate change (Sinsel et al., 2020). Therefore, science teachers need to integrate renewable energy concepts into learning activities to raise students' awareness of climate change issues. Integrating renewable energy concepts into education not only raises awareness but also equips students with the knowledge and skills necessary to innovate, drive future advancements in this field, and create a more sustainable future (Annan-Diab & Molinari, 2017; Khanum & Haleem, 2023).

The integration of STEM (science, technology, engineering, and mathematics) with art is called STEAM (science, technology, engineering, art, and

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mathematics), the aim of which is to increase student involvement in STEM topics through self-expression, aesthetics, and interdisciplinary projects (Engelman et al., 2017). The integration of art in STEAM is expected to make learning more meaningful, because students are involved in realizing the learning competencies they must achieve in real form in the form of work (Mu'minah & Suryaningsih, 2020). The STEAM approach is defined as the integration of two or more scientific disciplines in solving real-life problems. The STEAM approach can support student creativity (Aguilera & Ortiz-Revilla, 2021). STEAM education aims to produce well-rounded, innovative thinkers who are prepared to tackle complex problems in a rapidly changing world.

STEAM education is a teaching approach that fosters the learners' interest in STEAM courses by fostering their individual capabilities of expression, innovation, and aesthetic perception (English, 2017). STEAM activities can also attract the attention of students, encourage and improve their creativity (Khamhaengpol et al., 2021). Projects and activities in STEAM education often involve collaborative efforts (Hawari & Noor, 2020). Students work in teams, learn to communicate effectively, and leverage each other's strengths to achieve common goals. STEAM education relies heavily on hands-on activity and experiential learning. Students engage in projects and activities that require them to apply theoretical knowledge in practical, tangible ways (Videla et al., 2021). STEAM education enables students to learn cooperatively through "learning by doing", to solve practical problems through practical processes, and to connect knowledge with real life (Hsiao & Su, 2021).

A science kit is a collection of materials and instructions that are packaged together and used as learning media to improve understanding of science (Dickerson et al., 2014). The science kit can help develop students' cognitive skills, such as observation, analysis and interpretation (Lederman et al., 2023). Through hands-on experience with scientific concepts, students can develop a deeper understanding of how nature works. Most science kits involve students in hands-on learning activities related to creating questions, collecting data, interpreting data, and including assessment (Jones et al., 2012). Linn & Miller (2005) emphasizes the importance of collaboration and social interaction in science learning. Linn & Miller also revealed that the Science Kit can provide opportunities for students to work together, share ideas, and build students' communication and teamwork skills.

The Renewable Energy STEAM Kit was developed with the aim of making complex renewable energy concepts accessible and engaging for students. The kit includes materials and instructions for building solar-powered devices, wind turbines, and small-scale hydroelectric generators. It also incorporates artistic elements, such as designing aesthetically pleasing structures and creating visual presentations of energy concepts.

Developing a STEAM (Science, Technology, Engineering, Arts, and Mathematics) Kit involves integrating various educational theories and principles to create a comprehensive and effective learning tool. The theoretical basis for such a development can be categorized into several key areas. Constructivism, as proposed by Jean Piaget and further developed by Jerome Bruner, emphasizes the importance of active learning. According to this theory, learners construct their own understanding and knowledge of the world through experiences and reflecting on those experiences (Ozdem-Yilmaz & Bilican, 2020). A STEAM Kit designed with constructivist principles encourages students to actively engage in hands-on activities, experiments, and projects, facilitating deeper understanding and retention of concepts.

David Kolb's Experiential Learning Theory suggests that learning is a process whereby knowledge is created through the transformation of experience. Kolb's model involves four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kayes & Kayes, 2021). A STEAM Kit designed with this theory in mind provides students with concrete experiences (e.g., building models, conducting experiments), encourages reflection (e.g., discussing outcomes, comparing results), facilitates conceptual understanding (e.g., connecting activities to theoretical principles), and promotes experimentation (e.g., modifying designs, testing new ideas).

Lev Vygotsky's Social Constructivism theory highlights the importance of social interaction in learning. According to Vygotsky, learning is a social process, and knowledge is constructed through interaction with others (Taber, 2020). A STEAM Kit based on this theory encourages collaborative projects, peer-to-peer learning, and group problem-solving activities. It supports the idea that students learn better when they work together, share ideas, and construct knowledge collectively.

Howard Gardner's Theory of Multiple Intelligences posits that individuals possess different kinds of intelligences, including logical-mathematical, spatial, linguistic, musical, bodily-kinesthetic, interpersonal, intrapersonal, and naturalistic. A well-designed STEAM Kit incorporates activities that cater to a variety of intelligences, ensuring that students with different strengths and learning styles can engage and succeed. For instance, a STEAM Kit might include building projects for bodily-kinesthetic learners,

drawing and design tasks for spatial learners, and group projects for interpersonal learners.

The development of a STEAM Kit is underpinned by a rich theoretical foundation that draws from constructivism learning theory, experiential learning, social constructivism theory, and multiple intelligences theory. By integrating these theories, a STEAM Kit can provide a multifaceted, engaging, and effective educational experience that prepares students for the complex, interdisciplinary challenges of the future.

There are several reasons to conduct this research, like promoting sustainable education, enhancing creativity and innovation, improving science educational tools, and contributing to educational goals. The global shift toward sustainability highlights the importance of educating students about renewable energy. By analyzing project outcomes, this research can assess how well the STEAM kit educates students about renewable energy sources, which is crucial for fostering environmentally conscious future citizens. The integration of STEAM education is also designed to enhance creativity and problem-solving skills. This research helps determine how effectively the kit fosters these skills, particularly in relation to creative person, process, and product dimensions.

The Renewable Energy STEAM Kit represents a novel approach to achieving educational goals. By combining hands-on activities with interdisciplinary learning, this kit aims to engage students in exploring renewable energy in an interactive and meaningful way. The novelty of this kit is in the use of the STEAM learning approach. The development of STEAM-based science kits will potentially make students more active, challenged, and try to solve a problem in learning, especially in the Renewable Energy Sources material. This article examines student responses to the Renewable Energy STEAM Kit, highlighting the impact of this innovative educational tool on their engagement, understanding, and enthusiasm for renewable energy topics. Through analyzing these responses, we gain insights into the effectiveness of the STEAM approach in fostering a deeper connection between students and sustainable energy practices.

Method

The study involved 31 students who participated in the learning project using Renewable Energy STEAM Kit. Teacher and observer overseeing the activities were also included to provide observational data. Data was collected through survey, observation, and interview to gather student's responses about their experiences from learning activities using Renewable Energy STEAM Kit. Data processing utilized descriptive quantitative methodologies to derive significant insights from the provided data. Quantitative analysis was carried out with descriptive statistics to summarize the survey and assessment data. Each question was statistically represented, with table showing percentage distribution of responses. Descriptive statistical methods, including editing, coding, categorizing, and tabulating questionnaire items, were employed for data analysis.

Result and Discussion

The Renewable Energy STEAM Kit provides students with hands-on tools and materials, such as mini solar panels, wind turbines, water turbine components, and also learning module to explore and understand the principles of renewable energy through interactive and practical activities. The kit was also validated by experts to ensure its educational effectiveness and alignment with learning objectives. After the expert validity, the kit was tested on a small scale of students to ensure its feasibility.

Students' Project Outcomes

The learning project utilizing the Renewable Energy STEAM Kit involves a structured and immersive process designed to engage students comprehensively. It begins with an introduction to fundamental renewable energy concepts, facilitated by clear and interactive instructional module. Students then form teams to do collaborative learning and idea exchange. They proceed to explore the kit's components, conducting hands-on experiments that demonstrate the principles of renewable energy. Throughout the project, students are encouraged to document their observations, analyze data, and draw conclusions based on their experiments. Teacher guides the process, providing support, and ensuring that all students understand the key concepts of renewable energy.

After conducting hands-on experiment and assembling the Renewable Energy STEAM Kit, each group makes a unique miniature models. Before they make the miniature models, they have to determine the sketch design first. It helps them to construct the real miniature model. Figure 1 is an example of the sketch design made by students.

The sketch in Figure 1 illustrate the integration of renewable energy technologies within a rural environment. This model show how natural resources like water, sun, and wind can be harnessed to provide sustainable energy solution for citizens around the village. Surrounding the village are agricultural fields with irrigation systems powered by microhydro

energy. Small wind turbine and solar panel are also placed in these areas to supplement the energy supply. After students sketch the design, they will transform it into tangible products that address problems in innovative, effective, and refined ways, fostering future innovation development (Puchongprawet & Chantraukrit, 2022).

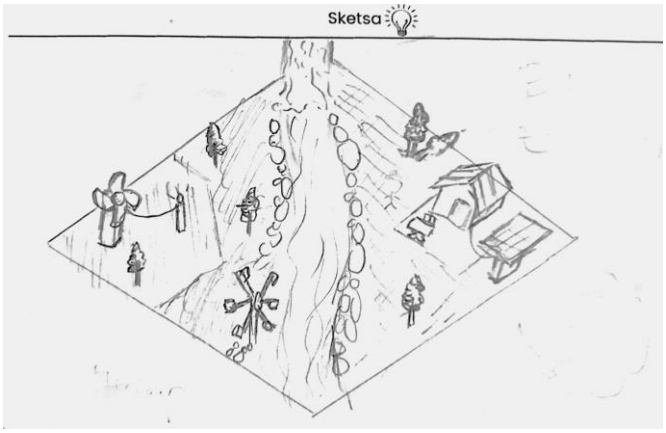

Figure 1. An example of a sketch made by students

Students work in groups using project-based learning (PjBL) model to construct their sketch design. Classroom learning that incorporates the STEAM approach is highly effective when paired with a PjBL model (Subiki et al., 2023). They place components that have been created, such as solar panel, wind turbine, and water turbine, following their designs. This phase involves problem-solving and iterative adjustments as students refine their models. This enhances their communication and cooperative skills. This encouraged students to consider how they could enhance their models and performance on the modeling assignment (Lyon & Magana, 2021). Furthermore, learning project with STEAM approach also involves teamwork, allows students to collaborate, and shares ideas (Li et al., 2022; Hawari & Noor, 2020). Students feel joyful and motivated when learning with the STEAM PjBL model, and they find that it helps them better understand science concepts (Badriyah et al., 2020; Lestari, 2021). STEAM-based learning also can create a creative learning atmosphere (Rahmayanti et al., 2024).

The project culminates in presentations where students show off their findings and the miniature models they have constructed, integrating various elements such as colors, shapes, and sizes into functional designs. At this stage, teachers should promote students' active self-expression by encouraging them to create and present their own projects. This approach enhances their language proficiency, communication skills, and fosters development in social, humanistic, and artistic aspects (Chen et al., 2019). Figure 2 shows an example of creative product which presented by a group of students.

Figure 2. An example of a creative product from learning project using Renewable Energy STEAM Kit

According to Figure 2, students in a group tried to make a model of a village which near the waterfall. They placed all of renewable energy components from the STEAM Kit well. There were wind turbine in a field, solar panel besides the house, and also microhydro in the river. Students used a variety of materials to make that artistic model. They also combined colors, shapes, sizes, and shapes into one beautiful whole. The inclusion of artistic elements in the STEAM kit encouraged creativity and innovation (Graham, 2020; Presley et al., 2016). Students enjoyed designing visually appealing structures and incorporating artistic flair into their projects. This integration of art helped students see the connection between technical knowledge and creative expression, fostering a more holistic understanding of the subjects (Nutov, 2021). STEAM education can fostering motivation of students through new, interactive, and experiential teaching methods (Kersanszki et al., 2024). An understanding of science should be given to students by first showing them the process of that knowledge in real terms, then students can construct their own knowledge (Rahmad & Wulandari, 2024).

The other groups make the unique miniature models like a sustainable rice field, modern farm, sustainable green open space, etc. These models demonstrated their understanding and application of renewable energy concepts. These models serve as an educational tool, demonstrating how integrated renewable energy solutions can be applied in real-world scenarios to address energy needs while promoting environmental stewardship. The diversity and uniqueness of these models reflect the students' ability to innovate and creatively express their knowledge. The uniqueness of the models indicates that students were encouraged to think creatively and

develop their own designs, and also demonstrating their capacity for innovation. This aligns with the STEAM approach, which integrates artistic expression with scientific and technical learning (Guyotte et al., 2014). In science education, the STEAM approach can equip students with the skills to apply their knowledge in creating designs that serve as tools for addressing environmental issues through the use of technology (Setianingrum & Jumadi, 2023). The teacher's role is also crucial in fostering students' emotional well-being and motivation, ensuring they stay engaged in learning while also nurturing their creativity (Rahmatiah et al., 2023).

Through learning project using Renewable Energy STEAM Kit, students gain educational experiences that integrate multiple disciplines. It was offering a comprehensive approach in learning science. These projects which involve hands-on activities, combine several disciplines, such as science, technology, engineering, arts, and mathematics. Students might explore the concepts of renewable energy (science), utilize technological tools for data collection and analysis (technology), design and construct miniature models related to renewable energy (engineering), apply creative design principles to enhance their miniature model projects (arts), and use mathematical calculations to optimize their models' efficiency (mathematics). The STEAM-based learning approach not only deepens students' knowledge of science but also exposes them to other subjects like technology, engineering, art, and mathematics, highlighting the interconnectedness of these disciplines (Habibi, 2023). STEAM education according to Henriksen et al. (2019) is about integrating subject matter in a transdisciplinary way that engages people in creativity, problem solving, and project or problem-based learning, in addressing real-world problems.

Overall, the use of the Renewable Energy STEAM Kit has significantly impacted students' learning experiences and project outcomes. Through engaging in hands-on activities, students were able to integrate knowledge from multiple disciplines, including science, technology, engineering, arts, and mathematics. The projects fostered creativity, critical thinking, and problem-solving skills as students designed and constructed innovative models utilizing renewable energy concepts. It prepares them to think creatively and analytically, equipping them with the skills needed to tackle complex real-world problems.

Students' Responses of Renewable Energy STEAM Kit

In product development, researchers need responses from users regarding the product being developed. In this context, the users of the kit are students which participated in this research. The responses were gathered through questionnaire. Questionnaire of student's responses of Renewable Energy STEAM Kit was reviewed on five aspects, ease of use, interest, flexibility, benefit, and relevance (Zulirfan et al., 2021). This questionnaire use likert scale, 1 to 4 (strongly disagree to strongly agree). Table 1 shows the items of questionnaire to gather the data of students' responses of Renewable Energy STEAM Kit.

Table 1. Items of questionnaire

Aspect	Items
Ease of use	STEAM Kit is easy to assemble anywhere
	The STEAM Kit User Guide is easy to understand
Interest	Enjoy learning using STEAM-based project methods
	Students would like to do another STEAM project in the future
Flexibility	Use a variety of materials in doing STEAM projects
	Make various Renewable Energy products from STEAM Kits
Benefits	STEAM projects make science subjects more real and useful
	Feel enthusiast about learning science through the STEAM Kit
Relevance	The components in the STEAM Kit are relevant to the Renewable Energy concept
	The concept of Renewable Energy becomes easier to understand after using the STEAM Kit

Each aspect in Table 1 contains 2 relevant questions to gather student's responses. Ease of use means how simple and intuitive a product is to use (Qu et al., 2022). Interest means the level of curiosity, engagement, or attention that a person has towards a product (Setiawan, 2021). Flexibility means the ability of a product to adapt to different situations, needs, or user preferences (Ejaz, 2021). Benefits means the positive outcome or advantage gained from using a product (McNally et al., 2010). Relevance means relatedness or the degree to which something is closely connected or applicable to a specific context, situation, or individual's needs and interests (Cross, 2021). Each student which participated in this research fill the questionnaire according to their feeling after using Renewable Energy STEAM Kit. Table 2 is the detail result of students' responses about Renewable Energy STEAM Kit. According to Table 2, we can make the graph for each aspect. Figure 3 shows the graph of the average percentage of students' responses regarding Renewable Energy STEAM Kit.

According to Figure 3, 32.3% of students agreed and 62.9% strongly agreed that STEAM Kit is easy to use. Only 5% of students who stated disagreed. It indicates that the instructions and components are

user-friendly and allowing students to use the kit with minimal difficulty. Such ease of use is essential for allowing students to concentrate on learning and experimenting rather than dealing with technical challenges. According to the interview process, students said that Renewable Energy STEAM Kit is easy to use at home, classroom, laboratory, or outside the classroom. The user guidance makes the experimentation easier. It allows users to easily adapt and personalize their learning experiences with the kit, fostering creativity, experimentation, and deeper understanding of renewable energy principles. The kit is considered safe for use as it does not include any toxic or flammable materials, sharp objects, or items that are prone to breaking easily (Zulirfan & Yennita, 2022).

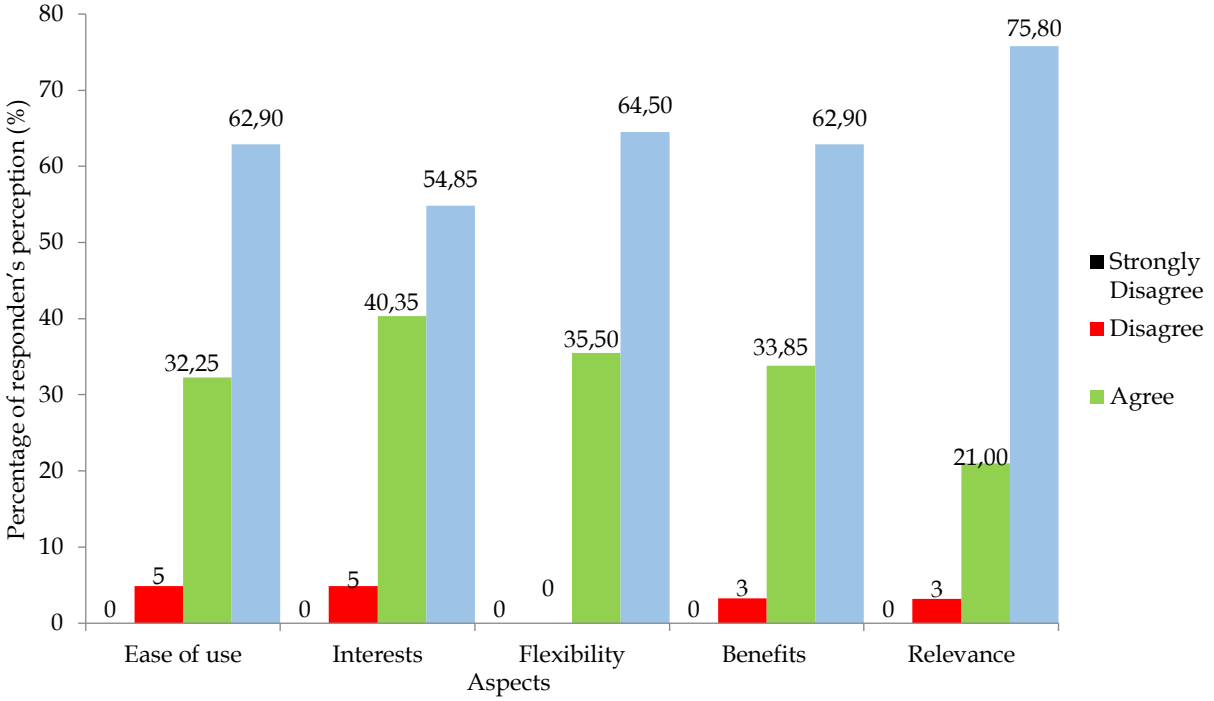

Figure 3. Graph of the average percentage of student responses from each aspect

Table 2. Percentage of each aspect about students' responses of Renewable Energy STEAM Kit

Aspects	Percentage of each aspect (%)			
	Strongly disagree	Disagree	Agree	Strongly agree
Ease of use	0.00	6.45	41.94	51.61
	0.00	3.22	22.58	74.19
Interest	0.00	3.22	32.25	64.52
	0.00	6.45	48.39	45.16
Flexibility	0.00	0.00	45.16	54.84
	0.00	0.00	25.81	74.19
Benefits	0.00	0.00	25.81	74.19
	0.00	6.45	41.94	51.61
Relevance	0.00	3.22	22.58	74.19
	0.00	3.22	19.35	77.42
Average	0.00	3.22	32.58	64.19

A total 40.4% of students agreed and 54.9% strongly agreed that STEAM Kit is interesting. While 5% of students stated disagreed. The high level of agreement (95.3%) suggests that the kit successfully engages students and captures their interest. Engaging students is critical for effective learning, as it maintains their motivation and enthusiasm. The low percentage of disagreement indicates that the kit's content and activities are generally well-received, making it a valuable tool for sparking student curiosity and participation. According to observation, almost all of students participated well in the process of the project. They felt interested when they saw and assembly the kit with their friends. Kit was interesting for them because it was the first time, they had made a project related to learning science (Zulirfan & Yennita, 2022). Furthermore, teaching through an integrated approach can enhance interest in STEAM content, particularly when introduced to students at an early age (Barlex, 2011).

A total 35.5% of students agreed and 64.5% strongly agreed that STEAM Kit is flexible. It means that there are no students who disagree that the kit is flexible. The unanimous agreement on the kit's

flexibility highlights its adaptability to different learning environments and teaching styles. This flexibility allows teachers to integrate the kit into various curricula and instructional methods, enhancing its utility as an educational resource. The absence of disagreement underscores the kit's design effectiveness in catering to diverse classroom needs. STEAM kit facilitate students to solve the contextual problem (Hamimi et al., 2024). Lecturer involvement in learning is also crucial for creating engaging and stimulating experiences for students, ensuring that the learning process remains interesting and avoids becoming monotonous (Rozi & Ruyani, 2024).

A total 33.9% of students agreed and 62.9% strongly agreed that STEAM Kit is beneficial. Only 3% of students who stated disagreed. A combined 96.8% of students acknowledging the benefits of the STEAM Kit indicates that it positively impacts their learning. This perception of benefit likely stems from the kit's ability to enhance understanding, foster critical thinking, and provide hands-on learning experiences. The minimal disagreement suggests that the kit meets educational objectives effectively for the vast majority of students. Teaching kit in research provide benefits in the formation of positive attitudes and increasing knowledge in renewable energy learning related to energy-saving behavior and carbon reduction (Chou et al., 2015). The use of the Science Kit as a tool in science education through the experimental method aims to enhance students' knowledge and skills to their fullest potential (Budiastra et al., 2022). The STEAM-integrated PjBL model also require active participation from students both individually and in groups (Luh et al., 2023). Through group collaboration, students engage in problem-solving investigations, enabling them to construct the essential concepts of the lesson from their discoveries (Sarjani et al., 2023).

A total 21.0% of students agreed and 75.8% strongly agreed that STEAM Kit is relevant. Only 3% of students who stated disagreed. The overwhelming agreement (96.8%) on the kit's relevance indicates that students see a clear connection between the kit's content and real-world applications. This relevance is essential for making learning meaningful and applicable to students' lives, particularly in understanding the importance of renewable energy in addressing global challenges. Utilizing a kit or teaching aids in science education provides an added advantage for students, as it allows them to grasp multiple concepts simultaneously by engaging with their environment (Erlina et al., 2022). The high percentage of strong agreement suggests that the kit effectively addresses contemporary issues and aligns well with students' interests and future aspirations.

The Renewable Energy STEAM Kit proved to be an effective tool for engaging students in the study of renewable energy. The hands-on, interdisciplinary approach captured students' interest, enhanced their understanding of key concepts, and fostered creativity and collaboration (Kim et al., 2019). There is also increase in students' conceptual understanding after they utilize STEAM activity (Aurelia et al., 2023). By integrating renewable energy education into STEAM activities, educators can inspire the next generation of innovators and problem-solvers to contribute to a sustainable future (Abdurrahman et al., 2023).

Conclusion

The learning project using Renewable STEAM Kit results a creative outcome. Teachers and observers agreed that learning outcomes are awesome, unique, and creative. Students were able to integrate knowledge from multiple disciplines and construct creative product. The projects also fostered creativity, critical thinking, and problem-solving skills as students designed and constructed innovative models utilizing renewable energy concepts. Average 96.8% of students agreed and strongly agreed that the Renewable Energy STEAM Kit is easy to use, interest, flexible, benefit, and relevant. Only 3.2 % of students that disagreed about that statement. The feedback and observations underscore the Renewable Energy STEAM Kit's success in being user-friendly, engaging, flexible, beneficial, and relevant to students' educational experiences and future aspirations. These findings affirm its effectiveness as an educational resource for promoting understanding and interest in renewable energy technologies.

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Conceptualization, L.R., S. B. R, S.; methodology, L.R.; validation, S. B. R. and S.; formal analysis, L.R., S. B. R, S.; investigation, L.R.; resources, L.R., S. B. R., S.; data curation, L.R., S. B. R., S.: writing—original draft preparation, L.R.; writing—review and editing, S. B. R., S.; visualization, L.R., S. B. R., S. All authors have read and agreed to the published version of the manuscript.

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No potential conflict of interest was reported by the authors.

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