CHAPTER I
INTRODUCTION

1.1 Background

Energy is essential for daily activities (Çoker et al., 2010). The main sector contributor to the energy supply is fossil fuels; however, their use is not sustainable. The combustion of fossil fuels generates greenhouse gases, which affect our environment by causing weather changes, rising sea levels, and health problems (Olabi & Abdelkareem, 2022). Moreover, the rapid growth of the world's population and societal improvements have led to a massive rise in energy demand (Dey et al., 2022). If we continue to use non-sustainable energy, it will furth er contribute to greenhouse gases, resulting in a huge negative impact. To address these challenges, we must explore and invest in renewable energy as the primary sustainable source of energy.

Renewable energy is energy derived from sources that naturally regenerate and can be used repeatedly without running out. This energy can be utilized directly or stored for future use (Deshmukh et al., 2023). Additionally, renewable energy offers benefits for the environment through lowering greenhouse gas emissions and preserving limited fossil resources for the future (Maradin, 2021). While the world faces environmental crises like climate change, renewable energy is gaining attention for its environmentally friendly and low-emission qualities (Ang et al., 2022). It is essential to utilize renewable energy as a source of energy to protect our Earth from environmental challenges.

At the start of the 21st century, renewable energy sources supplied about 14% of the world's total energy demand, grew to 17% in 2010, and is estimated to reach 50% of energy needs in 2040 (Amponsah et al., 2014). The most common renewable energy sources for clean power generation include solar, hydroelectric, wind, biomass, and geothermal energy (Ang et al., 2022). Switching from non-renewable to renewable energy should be the primary priority towards a sustainable future (Deshmukh et al., 2023). This shift can reduce greenhouse gases, pollution, and prevent environmental issues. On the other hand, successfully switching a source of energy from non-renewable to renewable energy requires public environmental awareness. However, the public needs to gain environmental awareness and participate in environmental activities (Rahmani et al., 2021). Public awareness also reflects knowledge about an issue or phenomenon; if the level of public environmental awareness is low, it means the knowledge about environmental issues is also low (Vasilev et al., 2021). Additionally, environmental awareness will support renewable energy, help people acknowledge the harmful influence of polluting energy, and foster environmental responsibility (Szeberényi et al., 2022).

Due to its geography, Indonesia has become one of the countries with an abundance of renewable energy sources. However, according to PRRI (2021), Indonesia successfully reduced greenhouse gas emissions by 25.93% in 2020, but weakened in 2021 to 23.55% (Raihan, 2023). Therefore, Indonesia's renewable energy target based on Government Regulation No. 79/2014 on the "National Energy Policy" of 23% by 2025 is at risk of not being reached (Lahope et al., 2024). This is concrete evidence that Indonesia still needs more awareness to fully implement renewable energy sources. One example is the use of the water sector through hydroelectric power as a renewable energy source. Indonesia has over 800 rivers that provide many water sources that support transportation, irrigation, and potential hydropower, with an estimated capacity of 75,000 MW (Tang et al., 2019). Therefore, water, as a renewable energy source, holds significant potential in Indonesia. However, hydropower development in Indonesia has not been effectively implemented; in fact, only 9% of this potential has been used (Dey et al., 2022).

This evidence presents a challenge for us and future generations to be more aware of how to utilize the great hydropower potential effectively. One way is through education. Education lays a foundation for understanding and addressing various challenges, such as environmental issues, through knowledge, principles, and innovative technologies, including renewable energy (Kandpal & Broman, 2014). It effectively provides future generations with the technical skills, mindset, and awareness of global issues. Education is also key to the nation's growth because it gives knowledge and responsibility and prepares skilled future workers (Ocetkiewicz et al., 2017). Students need to develop environmental awareness to address and contribute to solving environmental issues (Ekamilasari et al., 2021). Studies have shown that students' awareness of renewable energy remains low (Çakirlar Altuntaş & Turan, 2018). The research by Eshiemogie et al. (2022) stated that while 98.1% are aware of renewable energy, only 24% feel highly confident in their level of understanding. Other research indicates that students have a limited awareness of renewable energy, with only 30% of the research indicating knowledge of hydroelectric power (Buldur et al., 2020). The lack of strong awareness is due to inadequate knowledge of the subject and minimal exposure to practical activities. Other than that, the study on students' awareness, especially regarding renewable energy, still lacks articles.

Giving students practical experience and ample time to practice can enhance their comprehension and elevate the quality of their learning (Maragha et al., 2024). Practical activities can be carried out through project-based learning, which has been shown to be an effective approach for improving students' awareness of environmental issues (López & Palacios, 2024). At this time, students not only have to master cognitive aspects but also the skills. Project-based learning is an effective approach for involving students in practical activities, particularly when integrated with STEM. STEM education aims to prepare students to compete effectively and enter their preferred professional fields. Implementation supports students in developing critical thinking, creativity, logical reasoning, innovation, productivity, and the ability to connect learning to real-world situations (Widya et al., 2019). STEM education is gaining growing popularity in the field of education to create engaging learning environments that enhance students' curiosity in STEM subjects, equip them with valuable technological skills, and prepare them for success in future careers (Bryan & Guzey, 2020). With STEM education, students can develop hands-on skills that allow them to make a connection between theoretical knowledge and real-world applications (J. C. Chen et al., 2020).

The National Middle School Association supports the adoption of a unified STEM curriculum and instructional approach in middle schools (Thomas & Larwin, 2023). The middle schools provide all students with engaging and comprehensive training (Bryan & Guzey, 2020). STEM education was designed to equip students for the demands of the 21st century, requiring them to master the 4C skills: critical thinking, collaboration, creativity, and communication. Among these, critical thinking stands out as an essential competency for 21st-century skills for the learning process to enhance their critical reasoning and solve everyday problems (Adhelacahya et al., 2023).

The study from Khasani et al. (2019) stated that, based on the tests, students' ability to think critically about science topics results in 49.29%, which remains low. Through the survey in learning science from Azmi et al. (2021), results regarding student thinking skills, as measured by several indicators, including providing explanations, building basic skills, concluding, providing further explanations, and organizing strategies, showed that the results obtained in all indicators were below 50%. The results of this study demonstrate that students' critical thinking skills remain at a low level. The low students' critical thinking may be caused by the teachers still using the lecturing model, so the students pay attention to the teacher's explanations or take notes without any hands-on activity experience (Gelora Mastuti et al., 2022). As a consequence, students frequently take on a passive role, simply receiving information instead of actively engaging in their own learning.

To encourage a more active and student-focused learning experience, implementing STEM-PjBL can be beneficial. STEM has the potential to improve students' critical thinking by providing students with a practical approach to solving problems, especially addressing environmental issues (Novitasari et al., 2024). Furthermore, integrating critical thinking with STEM can drive students to have the ability to predict future problems and develop solutions. Students who experience project-based learning show higher levels of critical thinking skills and also experience a deeper understanding, making it recommended to use hands-on activities in learning science (Zulyusri et al., 2023). Based on this, STEM project-based learning is an efficient method to enhance students' critical thinking (Aureola Dywan et al., 2020).

Several studies on science topics in Indonesia have examined the impact of STEM project-based learning on students' critical thinking skills. Project-based learning can develop the ability of junior high school students to think critically in SMP Negeri 2 Amarasi Satap by about 36% (Samin et al., 2021). In the context of the dynamic electricity topic, STEM-based projects that focus on energy-efficient houses can enhance junior high school students' critical thinking skills by approximately 22% (Rahardhian, 2022). In the renewable energy topic, using STEM project-based learning in making solar cells can increase 15.47% students' critical thinking (Widiawati et al., 2023). In short, STEM Project-Based Learning has the potential to improve students' skills in critical thinking.

However, most studies still focus mainly on the STEM-PjBL, but few have explored how it can be strengthened by incorporating an engineering process, such as the Engineering Design Process (EDP). STEM education has weakened due to the lack of attention to engineering, even though it serves as an essential bridge connecting science, mathematics, and technology (Xue et al., 2023). Integrating STEM with EDP supports student-centered learning by guiding students to develop problem-solving skills, designing and creating, and gathering the relevant data, making it suitable for Indonesia's education, especially in the Merdeka Curriculum (Rahman et al., 2025). One of the studies implemented EDP in the context of renewable energy and found improvements in students' creativity (Sudrajat et al., 2023). Previous research has also shown that combining STEM-PjBL with EDP can enhance students' creative thinking skills (Fadiarahma Vistara & Wijayanti, 2022). However, few studies have specifically examined how EDP contributes to students' critical thinking skills and renewable energy awareness, particularly in the context of renewable energy.

This highlights a gap in current research and the need to explore STEM-PjBL with EDP in support of students' critical thinking and renewable energy awareness, especially in Indonesia. Therefore, this study offers novelty by exploring the integration of EDP with STEM-PjBL to enhance students' critical thinking and awareness of renewable energy by creating a simple hydroelectric (water turbine). The topic focuses on renewable energy because it not only aligns with global efforts but also provides students with opportunities to explore and address environmental issues. By addressing this gap, the title of this study is “Enhancing Renewable Energy Awareness and Critical Thinking Through EDP-STEM-PjBL on Hydropower”.

1.2 Research Problem

According to the background that has already been stated, the problem in this research is “How does the EDP-STEM-PjBL on hydropower enhance students’ renewable energy awareness and critical thinking?”

This research question is elaborated into three questions and listed below:

1) How are the students’ renewable energy awareness differences between the group using STEM-PjBL with and without EDP?
2) How are the students’ critical thinking skills differences between the group using STEM-PjBL with and without EDP?
3) How are the correlation between students’ performance and renewable energy awareness in the group using STEM-PjBL with and without EDP?
4) How is the correlation between students’ performance and critical thinking skills in the group using STEM-PjBL with and without EDP?

1.3 Operational Definition

1) Critical Thinking Skills

   Critical thinking skills in this study refer to the student's ability to analyze problems, formulate hypotheses or solutions, interpret the data, and make conclusions about renewable energy topics. Students' critical thinking skills are assessed using essay questions that focus on renewable energy as a topic. Students’ responses were assessed based on Ennis & Weir (1985), which focuses on determining actions, developing basic skills, observing, evaluating statements, identifying assumptions, and providing clarification.

2) Renewable Energy Awareness

Students’ awareness of this research focusing on the renewable energy topic. The students’ awareness will be measured using a Likert-scale questionnaire by Morgil et al. (2006) adopted by Kacan (2015). The statements that were developed and adjusted to reflect five aspects: knowledge, environmental impact, policy and investment, attitudes and opinions, and education and social responsibility.

3) STEM-PjBL Learning Model (with and without EDP)

This study was conducted in two groups: a control and an experimental class. The control class applied six stages of STEM-PjBL based on the George Lucas Educational Foundation Sumarni & Kadarwati (2020), which are (1) defining essential questions, (2) designing the project, (3) creating a schedule, (4) monitoring the progress of the project, (5) assess the project outcomes, (6) evaluate the experience. Meanwhile, the experimental class used an integrated model combining STEM-PjBL and the EDP, which includes seven stages proposed by the Massachusetts Department of Education in 2006, adopted from Siew et al. (2016). To avoid overlap, the integration resulted nine stage learning model, which are (1) Identify the need or problem, (2) Research the need or problem, (3) Draw/sketch possible ideas/solutions for the problem, (4) Select the best possible solutions, (5) Create Schedule, (6) Monitoring the progress, (7) Test the result, (8) Communicate the result, and (9) Evaluate experience. The activities in both groups were centered on a water turbine project and were adapted to match the structure of each model. Students' participation and performance throughout the learning process were analyzed using learning worksheets.

1.4 Research Objectives

The aims of this research, based on the problem that has been proposed, are:

a. To investigate the students’ renewable energy awareness differences between the group using STEM-PjBL with and without EDP.

b. To investigate students' critical thinking skills differences between the group using STEM-PjBL with and without EDP.
c. To investigate the correlation between students' performance and renewable energy awareness in the group using STEM-PjBL with and without EDP.
d. To investigate the correlation between students' performance and critical thinking skills in the group using STEM-PjBL with and without EDP.

1.5 Research Benefit

The result of this study is expected to provide the benefits listed below:

1) For students, this research allows them to learn and gain a deeper understanding by connecting science, technology, engineering, and mathematics using hands-on activities. This activity encourages students to become more aware of environmental issues and also enhances their critical thinking. This practical experience will lead students to develop a sense of responsibility and teamwork.
2) For a teacher, this research offers valuable insight into integrating STEM-PjBL with EDP, providing a practical approach that can be effectively applied in science classrooms. It equips teachers with a structured, hands-on learning model that promotes student engagement, supports critical thinking, and encourages awareness of renewable energy issues.
3) For researchers, this research contributes a clearer insight into the impact of STEM-PjBL integration with EDP on students' awareness and critical thinking skills of renewable energy. It offers other researchers to use the information as supporting data and reference for further STEM research. Additionally, researchers can find the strengths and weaknesses of this study that may help to develop and explore similar topics.

1.6 Scope of Research

This study focuses on applying the STEM Project-Based Learning model combined with the Engineering Design Process (EDP) in the context of renewable energy. This study aims to examine how effective this learning model in enhancing students' awareness of renewable energy and their critical thinking skills.

The study is conducted with two classes of 8th grade students at one of public junior high school in Bandung, which used Merdeka Curriculum. The topic will focus on renewable energy, and the project will concentrate on hydroelectric power (utilizing a water turbine).

This research is limited to the variables of renewable energy awareness and critical thinking skills. It does not explore other factors such as students' collaboration or motivation. The analysis is restricted to quantitative data obtained from student essays, awareness questionnaires, and performance on learning worksheets.