

## CHAPTER I BACKGROUND

### 1.1 Background

Indonesia as a developing country continues to rely significantly on fossil resources, notably oil because cheaper, and mature energy supplies are preferred, this orientation is expected to be long-term (Rahman et al., 2021). Energy consumption in several sectors including transportation has the largest energy consumption with approximately 45.76% of oil. In industries and households sector, the consumption rates are 31.11% for boiler steam generation purposes and 16.89% for electricity as well as LPG. Furthermore, the commercial sector consumes 4.97% of energy for lighting and air conditioning (Pambudi et al., 2023) This high reliance raises the possibility of a "blackout" of energy, which might be triggered by depletion of natural resources. Moreover, the consumption of fossil fuels like coal, oil, and natural gas recently has a big effect on emissions of carbon. This causes an increase in greenhouse gas emissions (GHG), leading to an unstable climate, as well as a rise in the earth's temperature and sea level (Li et al., 2022).

In 2020, Indonesia succeeded in reducing its GHG by 25.93%, but in 2021, it weakened to 23.55% (Pambudi et al., 2023). It's indicate that people's activities that account for significant greenhouse gases emission such as intensive use of fossil fuels tend to become a habits in society. Habits might persist even when individuals are unaware of their influence on the environment. For the most part, policies can leverage habits to promote sustainable practices (Mazar et al., 2021). Whereas, Sustainable Development Goals (SDGs) point 7 has mandated universal access to modern energy, enhancement of global renewable energy percentage, and enhancement of energy efficiency. To support the development of environmentally friendly policies related to SDGs 7, education as the main sources of it should generate environmental awareness.

One of the competencies that should students mastered to support the shift of society habits is action competencies. Students must own action competencies because it refers to people's ability to act to solve such challenges (Sass et al., 2020) Action competencies empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic, and environmental

impacts, from a local and a global perspective (Cebrián et al., 2020). The action will also make the executor to be persuaded of the need to modify behavior (Boyes & Stanisstreet, 2012). Through action-oriented learning students are pushed to challenge their preconceptions and apply new information and abilities to a variety of circumstances (Sipos et al., 2007). Previous study that explored about the action-based learning in renewable energy and energy efficiency, marked that after the learning students understand that each of them can contribute to themselves and to the surrounding by making simple changes in energy consumption rate (Friman et al., 2018). Hence, acquiring sustainability action is critical for altering behaviors and motivating community action, both of which are necessary for attaining a sustainable energy in the future.

However, the impact of learning activities to students' sustainability action still lack. Regarding the level of students' sustainability action, Indonesian students show lower performance than Malaysian students (Mohamad Saleh et al., 2022). Indonesian students' awareness of effects of, and concerns about, carbon emissions are not translating into action (Halloran et al., 2015). Another study also found that adolescence shows higher consumption rate of energy due to their deficiency of awareness to perform energy saving action (Fatmawati et al., 2018). This lower level of action driven by the lack of action-oriented knowledge focused on change management within the Indonesian Science Textbooks that all students utilize across all grade levels (Eliyawati et al., 2022). Research also found that teacher training still only focusing on to environmental education knowledge, which has not yet reached awareness, much less produced sustainable practices (Eliyawati et al., 2023). Another reason of undeveloped students' sustainability action is that conventional learning methods, in which the hope is that conceptual knowledge will eventually lead to application without provide the opportunity for students to directly apply their knowledge (Redman & Larson, 2011).

On the other hand, Creativity becomes one of the aspects that should be mastered by students to support action competencies which refers to solving those kinds of environmental problems. Creativity is part of the UN's facilitator of Sustainable Development Goals (SDGs), however understanding how Creativity may be cultivated and encouraged is critical in order to create effective solutions to

sustainability concerns (UNESCO, 2017). Creativity also can be a critical aspect of addressing environmental sustainability (Awan et al., 2019). Creativity that is guided by ethical action, will lead to cumulative changes that benefit society (Walsh et al., 2017). Creativity allows someone, for example, to search for ways of sustainable management of natural resources, alternative conflict resolutions and new business solutions and effectively use new technologies, and many more skills (Zamora-Polo & Sánchez-Martín, 2019). Creativity is highly essential to the development of clean and affordable energy. In order to generate energy from new sources, the use of affordable technologies, creative and innovative technological advances must be investigated (Hoque et al., 2022). This will greatly aid in addressing the world's energy demands. Therefore, creativity is essential for students to master in supporting action competencies for solving environmental problems, as it fosters innovative and effective solutions to sustainability concerns, guided by ethical action and benefiting society, while promoting sustainable management of resources and enhancing human well-being especially in achieving SDGs point 7<sup>th</sup>.

But based on fact in the field that was revealed by previous research students still experience weaknesses in Creativity, especially those related to flexibility and originality (Rosyadi, 2018). Indonesia remains in the low creativity index (0.037) which is ranked 81st out of 82 countries that are either developed or developing countries (Florida et al., 2011). A study conducted in Maluku, Indonesia also supports that students' Creativity is still at a very low level (Leasa et al., 2021). In term of science, a study revealed that 7<sup>th</sup> grade students' showed low level of scientific creativity with the mean of 26.99% (Usta & Akkanat, 2015). One of the factor that leads to students' low creativity is the rapid advancement of digital technology has led to an increase in copy-paste activities among students. This fact draw an identifiable trend: copy and paste activities are indicators of a reduction in student creativity (Maulyda, 2022). Traditional teaching models that still focus on teacher-oriented support the over-stimulated learning activity. It is possible that over-stimulation also puts pressure on students and harms creativity (Le et al., 2022). In conclusion, research highlights significant weaknesses in students' creativity in Indonesia causing by several contributing factors include the rapid

advancement of digital technology, which has increased copy-paste activities, and traditional, teacher-oriented teaching models that may over-stimulate and students, further hindering their creative development.

Education for Sustainable Development (ESD) that sparks by United Nation (UN) address the low level of students' sustainability actions as it proven that students' experience in ESD will affect their development of action competencies (Olsson et al., 2022). ESD aims to develop competencies that empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic, and environmental impacts, from a local and a global perspective (Cebrián et al., 2020). ESD Learning through project focuses on tackling environmental challenges through developing actual products or real-world action (Ferguson et al., 2022). ESD with the socialization aspect emphasized action that aims to introduce learners into a society that values active citizens (Sass et al., 2020). ESD can also be a proper learning to nurturing students' sustainability action through the knowledge sharing and collaboration (Chen &Liu, 2020). Several previous studies revealed that ESD has had positive trends in environmental sensitivity (Murray et al., 2014), and the willingness to identify environmental issues as personal concerns (Özsoy et al., 2012).

While Science, Technology, Engineering and Mathematics (STEM) Learning through development of projects has been proven by many previous research to be beneficial for improving students' Creativity (Hanif et al., 2019; Lou et al., 2017; Siew &Ambo, 2018; Triana et al., 2020). Students' affective characteristics of Creativity, such as imagination, curiosity, challenge, and adventurousness enhanced considerably after participating in STEM Learning (Lou et al., 2017). STEM-based learning will provide a stimulus for students to be able to design, develop and utilize technology to overcome a problem through technological engineering (Widodo, 2021). So, students will be required to utilized their imagination to make an innovation in designing solutions to a given problem in this context is energy crisis. Regarding the project of Renewable energy that has been developed within some previous research are Solar-Powered Robot (Wang &Guo, 2021), Dye-Sensitized Solar Cell (Chien et al., 2021), Hybrid Wind-Solar Power System (Beke, 2015), Wind propeller, Small-Scale Hydroelectric System, and Solar

Oven (García-Ferrero et al., 2021). Through the construction of these projects, the habit of utilizing the renewable energy technologies as the substitution of fossil fuel energy can be a proper move to create the SDGs number 7.

Based on the study above, combining STEM and ESD learning is expected to increase both creativity and sustainability action. Integrating STEM with ESD learning has proven to increase several students' competencies such as system thinking that able to help students in developing their own ideas in order to better solve complex and dynamic environmental issues (Abdurrahman et al., 2023; Kucuk & Sayse, 2018). Self-efficacy and students' engagement also proven to be enhanced during the STEM-ESD learning (Turner et al., 2021). STEM-ESD plays a significant role in increasing environmental literacy skills and help support sustainable lifestyle (Vallera & Bodzin, 2020). Another study showed that sustainability issues were effectively integrated into STEM learning to enhance the sustainability consciousness of junior high school students (Del Cerro Velazquez & Lozano Rivas, 2020; Firda et al., 2021). Another skills that developed supporting by STEM-ESD learning is critical thinking and sustainable awareness (Annisa et al., 2024).

However, there's still a lack of studies that explore about fusing STEM-ESD Learning within renewable energy projects to foster students' sustainability action and their Creativity in achieving SDGs point number 7 that is affordable and clean energy. To press the use of fossil fuels and avoid the "energy black out" the use of renewable energy must be introduced. As a result, the title of this study is "Investigating The Effect of STEM-ESD Based Learning on Renewable Energy Project towards Students' Sustainability Action and Creativity".

## 1.2 Research problem

According to the background stated, the research problem of this study is “How does students’ involvement in STEM ESD learning on the renewable energy project effect towards students’ sustainability action and Creativity?”. Based on the research problem, the research attempts to investigate the following questions:

- a. How does the effect of students’ involvement in STEM-ESD Learning on renewable energy project towards students' sustainability action?
- b. How does the effect of students’ involvement in STEM-ESD Learning on renewable energy project towards students' Creativity?

## 1.3 Research objective

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

- a. To investigate the effect of students' sustainability action through the involvement in STEM-ESD Learning on renewable energy project.
- b. To investigate the effect of students’ involvement in STEM ESD Learning on renewable energy project towards students’ creativity

## 1.4 Operational Definition

- a. Renewable energy project

The renewable energy project is a learning of Energy topic specified in Renewable Energy creating a product that utilize wind, water, or solar energy. The student will be welcome to create a product of renewable energy as creatively as they can by using STEM learning stages consisting of Problem identification, Think about the solutions, Solution Design, Testing, and Re design. After the students done the product, they will be asked to share the information about their product through the social media.

- b. Creativity

In this research creativity defined as students' ability to invent a novel and fitting products as a solution to energy crisis problem that related to SDGs point 7. Students’ final product will be assessed through the rubric named Creative Product Analysis Matrix (CPAM), 3 creative dimensions provided in this rubric are

novelty, resolution, and elaboration with the highest score is 3 and the lowest score is 1 (Besemer, 1998). Apart from the researcher, in the last meeting teacher and all students' are also assessing the creativity of the students' products by filling the rubric that has been provided. The result later converted into percentage and determined based on the criteria that presented in chapter 3.

c. Sustainability Action

This study emphasize the sustainability action as students' actions and ability to act and participate for achieving sustainability particularly on energy aspects respective to 7<sup>th</sup> SDGs. Sustainability action is measured using Environmental Citizenship Questionnaire (ECQ) with 4-likert scales and comprises of past and present actions, competences, and future action (Hadjichambis &Paraskeva-Hadjichambi, 2020). Pre-test and post-test of students' sustainability action presented in an online form that students from both experimental and control classes must fill out before and after Renewable Energy Learning. The result of students' sustainability action later analyzed by using hypothesis test through IBM SPSS program.

### 1.5 Limitation of problem

- a. The sustainability action in this study refers to students' action plan measured through the Environmental Citizenship Questionnaire (ECQ) which has two areas: past, present, and future action, and competencies. Thus this study cannot measure sustainability action in the form of students' direct action. Moreover, the sustainability action questionnaires are limited to the problems in the topic of renewable energy and relating to SDGs 7<sup>th</sup> goal which is clean and affordable energy.
- b. The Creativity of students in this study is the creativity of product that constructed by students within the application of STEM-ESD based learning. Creativity in this study assessed the creativity of students within groups, not as individual. Creativity only assessed at the end of STEM-ESD learning, so the changes in students' creativity cannot be tracked. Moreover, the learning stages do not take place fully in the classroom. There are also several learning stages

that take place outside the classroom, this causes the process of creativity development to be indescribable.

- c. The topic elaborate in this study is energy for 8<sup>th</sup> grade students' in Indonesia 2013 Curriculum. Learning goals of this topic are analyzing the concept of energy, various sources of energy, and change forms of energy in daily life including photosynthesis. In current study, the focus of research only on sources of energy sub topic that discuss about the concept renewable and non-renewable energy and the effect of the use of energy from both different sources. This study also integrate the ESD learning goals to the science learning activities focused on the learning goals for SDGs point 7 as will be elaborate in chapter 3.

### **1.6 Research benefit**

The research findings are expected to be able to conquer the following benefit aspects:

- a. For student

The result of this study is beneficial for students by improving their Creativity and sustainability action. Students have a new experience doing the renewable energy project.

- b. For teacher

This research provided alternative science learning in environmental issue topics for students. It will assist teachers in applying STEM-based learning related to increasing Creativity, sustainability action and creating an environment-based school by integrating Education for Sustainable Development into the curriculum.

- c. For researcher

The findings of this study benefit researchers by providing them with additional materials and data for people with similar interests. This study also benefits academics by providing data that may be used as a reference in future studies. Some of the research's strengths and weaknesses should be examined to enhance the outcome in this subject area.

## 1.7 Organization Structure of Research Paper

The title of this research is “Investigating the Effect of STEM-ESD Based Learning on Renewable Energy Project towards Students Sustainability Action and Creativity”. All research activities are reported and accounted for in a written thesis, following the UPI guidelines of Scientific Writing in 2021 edition. The organizational structure of this thesis is as follows:

### 1. Chapter I : Introduction

The context of this study provided in this section is the background of this research related to the gap between the ideal conditions of sustainability action and student creativity in supporting the fulfillment of SDGs point 7 with the real conditions in the field. It is also presented about how STEM-ESD based on renewable energy project can be a solution to the problem. Departing from the existing background in this chapter, the research question is also formulated, namely is “How does students’ involvement in STEM ESD learning on the renewable energy project effect towards students’ sustainability action and Creativity?”.

### 2. Chapter II : STEM-ESD Based Learning on Renewable Energy Project towards Students’ Sustainability Action and Creativity

Chapter II of this research discuss the literature review provided in previous findings about STEM-ESD Based learning on renewable energy project, students’ sustainability action, students’ creativity, and renewable energy discussion in energy topic. Discussed also how STEM-ESD based learning on renewable energy project for learning energy topic can resulting positive impact to students’ sustainability action and creativity.

### 3. Chapter III: Research Methodology

The research framework and technical instrument are encompassed in this chapter, including one of the Bogor junior high school students grade 8 as the sample of this research, including a research sample consisting of 60 8th grade students from one of the junior high schools in Bogor Regency divided into experimental and control classes, the instruments used were ECQ questionnaire and CPAM rubric, the data were analyzed by independent sample t-test, and the difference in the application of learning models in experimental and control classes.

#### 4. Chapter IV: Findings and Discussion

This chapter provide detail analysis of dependent variables in each indicator. Analysis of students' sustainability action showed that there's significant difference between control and experimental class. Elaboration of indicator of past, present, future action and competencies revealed that experiment class exhibit positive trends in sustainability action Result of students creativity showed that compared to previous research, the results of student creativity in this study are somewhat lower except in the resolution dimension. Mean score calculation reveal that group 4 appeared as the group with highest point.

#### 5. Chapter V : Conclusion, Implications, and Recommendations

This chapter encompassed brief conclusion about the results of students sustainability action and creativity between class that applied regular learning and the class that applied STEM-ESD based learning on renewable energy project. Implication revealed that STEM-ESD based learning can be used as an alternative learning model to increase sustainability action, but to increase creativity, some adjustments to the setting are needed. Some recommendation for future study contains how to apply STEM-ESD learning so that the output results are maximized.