

CHAPTER I

INTRODUCTION

1.1 Background

Our planet has experienced warmer and colder temperatures for millions of years. However, human activity is causing rapid warming, which releases greenhouse gas emissions. The greenhouse gases are being produced by industry, waste disposal, deforestation, and especially the use of fossil fuels (Wuebbles & Jain, 2001). Long-term reliance on fossil fuels has raised carbon emissions and sped up climate change (Azni et al., 2023). According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change can be directly or indirectly attributed to human activity by altering the composition of the global atmosphere.

People have relied on producing energy from fossil fuels for many years and throughout the world (Azni et al., 2023). The burning of fossil fuels creates many greenhouse gases, one of the gases is CO₂. Carbon dioxide (CO₂) is the greatest contributor to greenhouse gases. Most CO₂ is released from the incomplete combustion of fossil fuels such as coal, oil, and gas that are used for electricity production, transportation, and industrial processes (Institute, 2016).

Besides the large amount of CO₂ production from human activity, other important greenhouse gases include methane, nitrous oxide, black carbon, and various fluorinated gases (Institute, 2016). Due to the release of greenhouse gases, the environment has been impacted by air pollution, ozone depletion, global warming, heat waves, and floods (Azni et al., 2023). Despite the negative effects of burning fossil fuels on the climate, other energy sources will become more important since fossil fuels may run out by the early twenty-second century (Hu et al., 2015).

The higher the concentrations of greenhouse gases, the warmer the Earth gets. Climate change is already damaging our global natural environment. Some of them are rising seas, acidification of seawater, declining glaciers and snowpack, changes in the global hydrologic cycle, and the earth's surface warming temperature (Institute, 2016). Due to the worldwide scope of climate change's impacts, the

world must take climate action to cut carbon emissions and switch to a sustainable lifestyle. This is in line with one of the SDGs points, namely point 13 “Climate Action”. SDG 13 is an action towards lowering emissions and adapting to climate change (Louman et al., 2019). Taking immediate action can make future adaptation easier and more affordable. According to the UN Intergovernmental Panel on Climate Change, global emissions must be cut to 40% of their current levels to stabilise the atmosphere (Matawal & Maton, 2013).

Indonesia has an abundance of natural resources, including sunlight, wind, water, biomass, and geothermal heat. As a result, Indonesia has a significant potential for renewable energy in supporting the transition to clean energy (Qalbie & Rahmaniah, 2023). Renewable energy can reduce dependence on fossil fuels, which contributes to greenhouse gas emissions (Qalbie & Rahmaniah, 2023). However, despite its advantages, challenges remain to be addressed, such as the lack of infrastructure and limited public awareness. To fully realize the potential of clean energy in Indonesia, it is crucial to raise public awareness and educate people to take some action to reduce carbon emissions that cause climate change.

The education sector is one solution in addressing climate change, increasing awareness, and encouraging Indonesian people, particularly students, as the young generation, to take responsible action to overcome the climate crisis. Education for Sustainable Development (ESD) is a tool to achieve the Sustainable Development Goals (SDGs). ESD is a multidisciplinary concept that considers development from the social, economic, and environmental perspectives (Vilmala et al., 2022). Education for Sustainable Development (ESD) prepares learners to take action as citizens who are knowledgeable about environmental and citizenship issues and eager to engage in action that promotes sustainable development (Sass et al., 2021).

Action competencies must be owned by students. Sustainability action refers to the competence that individuals and/or groups have which focuses on solving the issues related to sustainable development (Sass et al., 2021). Actions are acknowledged as actions in the public sphere (affect the relations in societies) and private spheres (they affect the relations between individuals and societies) (Hadjichambis & Paraskeva-Hadjichambi, 2020). Furthermore, when considering action competence in sustainable development (ACiSD), the action intends to

resolve sustainability-related problems (Sass et al., 2022). Students who have sustainability action skills will live by paying attention to the impact of their activities which produce greenhouse gases. So that, students will live a sustainable lifestyle. Moreover, students who have good sustainability action can offer solutions to overcome the problem of climate change climate change and make a massive impact.

A person is thought of to be an action-competent if they are skilled at learning what actions they can take to contribute to a potential solution (Sass et al., 2021). Student action towards SDGs goals in Indonesia is relatively low. Studies in Riau reveal that the students' awareness experiences continuous growth, but not as a result of students' actions. A contributing factor to low student' action is the lack of environmental activities and projects at school (Ruslindawati et al., 2022). Similar situations have occurred also in several other countries such as Malaysia, Saudi Arabia and Taiwan (Alsaati et al., 2020; Chen & Liu, 2020; Hassan et al., 2010). Moreover, a previous study found that action-oriented knowledge that could help students switch to a more sustainable lifestyle is still missing from Indonesian school textbooks (Eliyawati et al., 2022). However, the impact of the school on students' sustainability action is still lacking. The awareness, knowledge, and attitudes are not enough to encourage students to take real actions that reflect sustainable lifestyle (Habibah & Irawan, 2023). Moreover, there is not much study on students' sustainability action competence in Indonesia.

Long-term sustainability requires some aspect such as innovations across the board and creativity in all fields (Orville, 2019). Generating a novel and suitable product, answer, or solution for an unrestricted assignment is referred to as creativity (Amabile, 2012). Creativity ability will be useful for students to create ideas to be implemented in action (Mróz & Ocetkiewicz, 2021). Moreover, in this era, creativity is a 21st-century skill that is needed by students in preparation for their future careers and deals with the advancement of technology (Hanif et al., 2019). A teacher must be able to cultivate students' creativity in order to foster students' creativity. Students who have good creativity will do innovative things from their idea solutions to solve climate change problems, for example making products that utilise natural resources, making products that can reduce greenhouse

gases or making products that can replace current products that contribute to greenhouse gases.

The curriculum that has been emphasized in the creativity aspect should be able to improve students' creativity. This is in line with the statement of the Association for Science Education in 2010 that the main purpose of science education should be enable students to make creative decisions that can influence society and the environment around them (Permanasari et al., 2021). However, according to Global Creativity Index in 2004 which compared the 3T metrics (technology, talent, and tolerance), Indonesia takes place 81st out of 82 countries with the global creativity index of 0.037 (Florida et al., 2011). In 2015, Indonesia is ranked 115 out of 139 countries with a global creativity index of 0.202 (Viorita et al., 2022). Moreover, due to the teacher's ability, students in Indonesia still have a lack of creativity skill (Hanif et al., 2019). Some areas of creativity such as adventure, curiosity, imagination, and challenge has been measured through STEM learning through projects in the classroom (Hanif et al., 2019).

Some study results indicate an improvement in sustainability action competence and creativity. Since students will be creating the product, ESD-based STEM learning has the potential to boost students' creativity. STEM project-based learning can be used as alternative teaching strategies in school because it gives good impact on students' creativity (Hanif et al., 2019). In STEM project-based learning, students will develop their ideas to create a product (Hanif et al., 2019). Furthermore, students' involvement in the STEM project-based learning could improve students' affective aspects of their creativity, including imagination, curiosity, challenge, and adventurousness (Lou et al., 2017). Another study revealed that STEM learning could change students' perceptions about the need for creativity (Bicer et al., 2017). Moreover, students realized that creativity is an important aspect when take an action to solve the problem in STEM disciplines (Bicer et al., 2017).

Furthermore, students can predict future problems and choose actions on solutions while thinking about sustainable development and environmental responsibility through STEM project-based learning with ESD (Suh & Han, 2019), especially related to SDGs 13 Climate Action. Through the Climate Hero project in

ESD-based STEM learning, students can develop their creativity and construct the project which motivates them to take action in the future regarding climate issues. In ESD-based STEM learning, students had to work on real-world problems related to sustainability (Faizah et al., 2024). In other words, sustainability action competency also could be improved. Another research showed that problem-based learning and project-based learning have been widely known as course models that support students acquire sustainability competencies (Kricsfalusy et al., 2018), including sustainability action competency.

However, based on the explanation above, there is limited research on the use of Climate Hero projects in ESD-based STEM learning to investigate sustainability action and students' creativity. The topic chosen is climate change because the topic describes the basic understanding to face real-life environmental challenges that caused by climate issues. Students will have the opportunity to learn the causes, the effects, and the way to overcome climate issues. As a result, the title of this study is "Investigating Students' Sustainability Action and Creativity through ESD-Based STEM Learning on The Climate Hero Project."

1.2 Research Problem

According to the background stated, the research problem of this study is "How does the involvement of students in the Climate Hero project through ESD-based STEM learning in students' sustainability action and students' creativity." Based on the research problem, the research attempts to investigate the following questions:

- 1) How does the involvement of students in the Climate Hero project through ESD-based STEM learning towards students' sustainability action?
- 2) How does the involvement of students in the Climate Hero project through ESD-based STEM learning towards students' creativity?

1.3 Operational Definition

a. ESD-based STEM learning on The Climate Hero Project

ESD-based STEM learning on The Climate Hero Project is a learning that uses STEM learning syntax where students conduct a Climate Hero project to

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create a product considering sustainable development aspects to overcome climate change problems. The main idea of this Climate Hero project is that students could make a product that could reduce the production of carbon emissions which causes climate issues.

b. Sustainability Action

Students' sustainability action refers to actions that students have taken or future action plans related to SDGs 13 Climate Action. Students' sustainability action in addressing climate issues is measured through a questionnaire with a 4-point Likert scale which is the result of modification and elaboration of instruments from the Environmental Citizenship Questionnaire (ECQ) (Hadjichambis & Paraskeva-Hadjichambi, 2020) with ESD Learning Goals (UNESCO, 2017).

c. Creativity

Student creativity refers to students' ability to create products that serve as solutions to climate problems. The creative products are made in the Climate Hero project through ESD-based STEM learning. In addition, students' creativity is assessed based on the creative products with an assessment rubric developed from the creativity product analysis matrix (CPAM) indicators from (Besemer, 1998) with a scale of 1 to 3 for each creativity criterion.

1.4 Limitation of Problem

Focusing on the research problem that has made before, this research has several limitations to produce a better outcome as follows:

- 1) Students' sustainability action in this study is based on the action plans they made, not on the actions they take. The sustainability action in this study is based on the Environmental Citizenship Questionnaire (ECQ) which has some areas: past, present, and future actions, and competencies. Moreover, the sustainability actions are limited to the problems in the topic of climate change and related to SDG's 13th which is Climate Action.

- 2) In this study, the creativity assessed is the creativity of the products produced by students in the Climate Hero project. In this study, the creativity of each individual was not measured, but based on the products made in groups. In the manufacturing process, students do the work in class and outside of school hours. Students' activities in the process of making the product were also not investigated in this study. Creativity in this study only profiles the product creativity of the experimental class without comparing it with the control class. The creativity of students in this study is the creativity based on three dimensions in creativity product analysis matrix (CPAM) which are novelty, resolution, and elaboration and synthesis. The criterion of each dimension is limited. For criteria of novelty dimension are original and surprise. For criteria of resolution dimension are valuable, logical, useful, and understandable. For criteria of elaboration dimensions are organic, elegant, and well-crafted.

1.5 Research Objective

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

- 1) To investigate the effect of students' involvement in the Climate Hero project towards students' sustainability action.
- 2) To investigate the effect of students' involvement in the Climate Hero project towards students' creativity.

1.6 Research Benefit

- 1) For student, they can enhance their sustainability action as well as their creativity. Students have a new experience in constructing Climate Hero project.
- 2) For teacher, ESD based STEM learning can be an innovation in teaching-learning activity to build an active learning and foster students' sustainability action and creativity.
- 3) For researcher, the findings of this study benefit researchers by providing them the data and material about students' sustainability action and creativity with ESD based STEM learning at junior high school level that may be used as a reference in future studies.

1.7 Organization of Research Paper

The research was structured based on the guidelines for writing a research paper from Universitas Pendidikan Indonesia 2021 edition. The arrangement of each chapter is shown below:

1) Chapter I: Introduction

This chapter contains the research background explaining the importance of ESD-based STEM learning research on the Climate Hero project on sustainability action and student creativity. In addition, the problems found related to SDGs 13 Climate Action, sustainability action, creativity are explained in this chapter.

2) Chapter II: Literature Review

This chapter contains concepts and theories that discuss ESD-based STEM learning on the Climate Hero project, student sustainability action, and creativity. This chapter also discusses previous research relevant to ESD-based STEM learning, the Climate Hero project, sustainability action, and creativity.

3) Chapter III: Research Method

Chapter III discusses the research procedure for investigating ESD-based STEM learning in the Climate Hero project on sustainability action and creativity. This study used a quasi-experimental design with a sample of 90 students in a private school in Bandung. The instruments used were questionnaires to measure students' sustainability actions and CPAM rubrics to assess students' product creativity, and the data were processed using excel and SPSS software.

4) Chapter IV: Results and Discussions

This chapter discusses the research findings and factors that influence students' involvement in ESD-based STEM learning through the Climate Hero project to answer the research questions that have been formulated. Moreover, the detailed elaboration is also carried out on the indicators in each variable and equipped with tables and figures.

5) Chapter V: Conclusion, Implication, and Recommendation

This chapter presents the research conclusions that answer the research questions. This study concludes that ESD-based STEM learning positively affects students' sustainability actions and can develop students' creativity. Therefore, Climate Hero project learning through ESD-based STEM learning can be implemented to improve students' sustainability actions and creativity. For future research, the researcher recommends conducting this project for a longer period of time and students' creativity should also be measured before the learning process to determine the improvement of students' creativity. In addition, concept mastery variables can also be added to measure students' understanding of climate change material after doing the project.