CHAPTER I
INTRODUCTION

1.1 Background

Education is one of the pillars to achieve Sustainable Development Goals (SDGs). The fourth goal of the SDGs emphasized "Quality Education," which tackles Education for Sustainable Development (ESD) and requires that every student acquire the knowledge and skills needed to promote sustainability (Giangrande et al., 2019; Kopnina, 2020). In today's world, the most visible goals of public education are the establishment of a literate society in order to achieve a more sustainable future (Dawson & Siemens, 2014; Waltner et al., 2019; Warren et al., 2014). Multiliteracy represents one of the core competences of the knowledge-intensive society, in which students need to comprehend, create, and evaluate many types of information, assess their surroundings, and perceive its cultural variety, comprehend various modalities of cultural communication, and develop their personal identity (Kangas & Rasi, 2021; Leino et al., 2004). Yet, according to PISA 2018 result, Indonesian students have the lowest level of multiliteracy (Prihatini, 2021). Low literacy level resulted on the nation's low productivity, and hence on the level of national welfare. Therefore, it is necessary to increase students' literacy skills (Ramdhani et al., 2021). Because, students who have good multiliteracies competence are expected to become smart, healthy, courageous, and highly competitive Indonesian human resources in the industrial era 4.0 which is part of the 2020-2024 national research priorities (Prihatini, 2021).

Multiliteracy is defined as multiple literacies in various languages and modalities of representation (Usanova & Schnoor, 2021). It incorporates a variety of literacies and provide students with the opportunities to improve their learning environments with the use of technology (Suwalska, 2021). Multiliteracy is a goal in itself: a unit comprising of knowledge, competences, values, attitudes, and reasons that every modern citizen should have (Kangas & Rasi, 2021). In recent years, the topic of ESD competencies in the domain of sustainability has been a major focus (Cebrián et al., 2020). The integration of multiliteracy and ESD context can result in a more effective learning strategy to achieve SDGs. The concept of

sustainable development is centered on simultaneously addressing the three pillars of ESD, which are social, economic, and environmental objectives (colloquially) known as People, Profit, Planet) (Kioupi & Voulvoulis, 2019; Kopnina, 2020). By analysing the three pillars of ESD, we can define that there were several literacies related to one another.

There are three literacy that represents the three ESD pillars, which are STEM literacy, environmental literacy, and sustainability literacy. STEM literacy is vital for sustaining economic growth because it can fill the demand for a 'skills pipeline' of workplace-ready people with specific STEM abilities (Falloon et al., 2020). STEM literacy includes the STEM knowledge, skills, and understanding required to engage with ideas and processes influencing personal health decisions, as well as engaging with STEM interactions as part of a larger socio-political circumstances (Braund, 2021). In the environmental context, it is obvious that environmental literacy is needed. Environmental literacy includes common concepts, such as the ability to perceive, interpret, and make informed decisions about environmental issues, understand ecosystems, and be aware of the importance of natural phenomena. Environmental literacy in science and other disciplines is important because it enhances the protection of nature which support the environment on the ESD pillars. The concept of the environment should be presented with a broad perspective in science curricula and textbooks to achieve a sustainable future (Kaya & Elster, 2019). Moreover, a sustainability literate person understands the need for change to a sustainable way of doing things, individually and collectively. They should have sufficient knowledge and skills to decide and act in a way that favours sustainable development (Akeel et al., 2019). The integration of STEM literacy, environmental literacy, and sustainability literacy is proposed to support the context of ESD to reach sustainable development.

However, several studies indicates that the empowerment of those literacies was not optimum. Previous study by Jalmo (2020) indicates that science learning in Junior High School has not optimally integrated STEM Literacy, resulted on the low ability of the students to apply science, technology, engineering, and mathematics consciously in their daily lives. Other survey on the effect of educational program into students' environmental literacy by Hermawan (2022)

shows that the students' environmental literacy was in moderate level and the empowerment of environmental literacy through the learning was not optimal. Likewise, Qureshi (2020) found dissonance between students' beliefs and their actions towards the sustainable literacy, which can be fixed by integrating sustainable living practices into the curriculum.

Moreover, a study conducted recently in 22 Asian countries showed that education places emphasis on preparing students for competitive participation in the global economy, rather than becoming critical and responsible members of society in alignment with the objectives of ESD (Kioupi & Voulvoulis, 2019). A study conducted by Burmeister & Eilks (2012) found that the teachers' readiness to implement the goal of integrating ESD into science education is considered low. The teachers' knowledge is limited to a piece of vague information in the theoretical sense, with only a few teachers being able to pose any clear, theory-supported concepts when it came to either sustainability or ESD. ESD requires a comprehensive approach to taking up socially relevant issues, which requires the teacher to deal with sustainability, sustainable development, and their overall meaning. Teachers need specific subject matter knowledge in science-related issues which can form a core to start ESD teaching in the class. (Kioupi & Voulvoulis, 2020). Therefore, there is a need to provide teachers with both a better understanding of the curriculum and the necessary pedagogies to integrate ESD into the learning process.

Correspondingly, with the emergence of the concept of Education for Sustainable Development (ESD), science learning in schools is required to help improve the development of economic knowledge, teaching and learning activities, and understanding of the environment (Fakhrudin et al., 2021). This can be done by asking students to solve environmental problems, then they can analyze these problems based on data from problems found in real life (Yahaya et al., 2021). STEM has become one of the learning models that are widely introduced for the potential to build multiliteracy. Previous research stated that besides being able to create a pleasant learning atmosphere, STEM can help improve student learning outcomes to problem-solving abilities (To Khuyen et al., 2020). The integration of STEM-ESD-based learning leads students to find solutions to problems related to

science and technology through the creation of creative ideas based on the perspectives of welfare, environment, and public health.

However, preliminary study shows that one of the obstacles is that STEM learning in the classroom was not properly conducted. This causes the meaning of STEM learning has not been achieved. Furthermore, previous research indicates that STEM learning in secondary schools has not integrated STEM literacy optimally, so students have not been able to apply the concepts of science, technology, engineering, and mathematics in everyday life (Ibrohim et al., 2020). To implement effective and efficient STEM-ESD-based learning, teachers are required to develop science learning models that integrate STEM with ESD to increase students' multiliteracy (To Khuyen et al., 2020).

Preliminary study was done by carrying a case study on the implementation of STEM learning in the class. The results shows that teachers have difficulties in integrating STEM-ESD in science learning for several reasons, (1) there has not been much socialization of STEM-ESD-based science learning, (2) teachers have not fully understood the stages of STEM-ESD-based science learning, (3) there are not many references that can be accessed by teachers regarding STEM-ESD-based learning. The results of other studies show that teachers' abilities are still weak in designing, implementing, and assessing STEM-ESD learning and STEM-ESD learning strategies which are still separate/not integrated. While the characteristics of STEM-ESD learning are learning that is integrated with the context of problems in everyday life to produce creative solutions oriented to the three pillars of ESD. If science learning is designed with a STEM-ESD approach, it is hoped that it can initiate students' thinking to learn to provide solutions related to welfare through science learning (green economy). Past research regarding STEM-ESD-based learning has been done, but there is no research referring to the integration of STEM-ESD-based learning with students' multiliteracy, especially in the context of secondary school. Therefore, this research aims to develop a STEM-ESD learning model in science to enhance students' multiliteracy. To optimize the learning outcome, it is important to profile the students' needs.

In that case, profiling students' learning style can help the teacher to identify the students' needs. Learning styles are considered an important factor in the

learning process that has great potential to facilitate learning for students (Haryana et al., 2020). In order to deepen the analysis of the factors affected the learning process, it will be analyzed how each learning style match the implementation of PjBL -STEM-ESD model. Learning styles are styles or individual learning techniques that act with their environment, to process, interpret and obtain information, experiences, or desirable skills (Othman & Amiruddin, 2010). Learning style is a practice that covers a spectrum of modalities, preferences, and strategies that may be assessed by knowing an individual's preference for different information and mental activities. From the cognitive aspect, learning style can be referred to various methods in perception creation and information processing to form concepts and principles (Othman & Amiruddin, 2010).

For instance, Fleming and Mills (1992) developed an inventory of learning styles known as VARK. Based on sensory modality, Neil Flemming categorized four modes in VARK which are visual (V), aural (A), read/write (R), and kinaesthetic (K) (Ahmad Chaudhry et al., 2020; Perdue & Marcis, 2014). Visual learners prefer printed information through diagrams, flow charts and arrows. Auditory learners like heard information and enjoy discussions, lectures, and tutorials. Read-write learners love printed words and texts as a means of information by textbooks, lecture notes and hand-outs. Kinesthetic learners internalize information best when physically involved in hands on activities.

The "Meshing Hypothesis" states that the learning outcomes could be highly achieved if learning was matched with predominant learning style of the learner (Md Zain et al., 2019). The idea of the importance of understanding learning styles is also supported by Kazu (2009) who said it is important for individuals to know their preferred/favorite ways of learning because it will make the learning process becomes more effective (Haryana et al., 2020). Finding showed that students which their learning style matched with the technique of material presented in online course have higher scores significantly compared to those in which their learning style were mismatched. It is supported by Bacon and Miller who found that students' learning result is significantly enhanced if their learning styles are properly coordinated to the learning environment (Sintia et al., 2019). Student motivation and performance improvements when instruction is molded to student

learning styles. Similarly, knowing one's learning style can minimize learning time, enhance student engagement in the process, and increase learning outcome and efficiency (Fahim et al., 2021). The importance of knowing students' learning style brought the urgency to analyze how the learning strategy used facilitate each learning style.

The need of this research implies on the recent curriculum used in Indonesia. *Kurikulum Merdeka* that was applied since 2022 stated that the learning process must include integrated and differentiated learning, leading to create citizen that are critical, creative, collaborative, and aware of the global issue. Differentiated learning is a way for teachers to meet the needs of each student since students can learn according to their abilities, preference, and their respective needs. Profiling the students' learning style and elaborate each preference into the learning process can support the concept of differentiated learning. The integration of STEM-ESD into PjBL is able to cover those needs of the curriculum. It can bring the students to experience integrated learning that leads to enhance their multiliteracy that includes creativity, critical thinking, and collaborative skill. Furthermore, the integration of ESD enhances students' awareness in global issue, analyses nation issue, bring them to solve daily life problem that leads them to pursue sustainable development that in line with the theme 1 on *Kurikulum Merdeka* which is 'Sustainable Lifestyle'. The topic of alternative energy was chosen due to the compatibility with the ESD and STEM framework. The issue of transition energy brought as the real-life problem in which the students are able to analyses and gives practical solution to the issue.

1.2 Research Question

The research problem of this study can be defined as "Does the integration of STEM-ESD into Project-Based Learning can enhance students' multiliteracy on alternative energy based on student's learning style?"

Based on the research problem, the research attempt to define the following questions:

1. What are students' learning styles?
2. What is the characteristic of STEM-ESD in PjBL?

3. How is the enhancement of students' multiliteracy after the implementation?
    a. How is the enhancement of students' STEM Literacy after the implementation?
    b. How is the enhancement of students' Environmental Literacy after the implementation?
    c. How is the enhancement of students' Sustainability Literacy after the implementation?

1.3 Research Objective

The research objectives of this research can be listed as follows:

1. Profile student's learning style.
2. To elaborate the characteristic of the integration of STEM-ESD into Project-Based Learning.
3. To explore the enhancement of students' multiliteracy after the implementation:
    a. Exploring the enhancement of students' STEM Literacy after the implementation.
    b. Exploring the enhancement of students' Environmental Literacy after the implementation.
    c. Exploring the enhancement of students' Sustainability Literacy after the implementation.

1.4 Research Benefit

This research is prospected to give benefits as shown below:

1. Provides teaching and learning guides for teachers to integrate the STEM-ESD into PjBL model into science learning, to enhance students' multiliteracy on alternative energy based on student's learning style.
2. Students can identify their learning styles and optimize their learning achievements, experience various science learning, and enhance their multiliteracy on alternative energy.
3. This research can be used as a reference to develop another study regarding the integration of STEM-ESD into PjBL in science, related with multiliteracy, and learning styles.

1.5 Operational Definition

1. The integration of STEM-ESD into Project-Based Learning

The learning model adopted in this research is the integration of STEM-ESD into PjBL. PjBL-STEM stands for project-based learning model and Science, Technology, Engineering, and Mathematics approach. The 5 learning syntaxes of STEM-PjBL (Project-based learning) by Laboy-Rush (2010) were used. It is consisted of Reflection, Investigation, Discovery, Application, and Communication phase. Education for Sustainable Development (ESD) acts as the learning context that supports the accommodation of the fourth goal of Sustainable Development Goals (SDGs). The concept of sustainable development is centered on simultaneously addressing the three pillars of ESD, which are social, economic, and environmental objectives. The ESD issue used was the energy transformation and the needs of energy alternative.

The learning process conducted in four meetings. The first meeting includes reflection and investigation phase, where student reflect on the energy deficiency problem and discuss the science concept of the energy alternative. The second meeting is discovery phase that requires the student to design a project related to solar energy as the energy alternative. Third meeting covers application phase where students apply science concepts to build and test their prototype. The last meeting is the communication phase in which students presents their prototype.

Observation sheet and video documentation was used to make sure that all the learning syntax was covered and the integration of STEM-ESD into Project-Based Learning has done perfectly.

2. Students' Multiliteracy

Multiliteracy in this research stans for several literacies that build up the ESD pillars (social, economy, and environment) in one individual. Therefore, the researcher focuses on environmental literacy, STEM literacy, and sustainability literacy as the components that build up students' multiliteracy in the ESD context.

STEM literacy builds up scientific literacy mathematics literacy, and technological and engineering literacy. In this research, the literacy domain was

limited to STEM Literacy knowledge only. So there are scientific literacy knowledge, Mathematics literacy knowledge, and technology Engineering Literacy Knowledge. Scientific and mathematics literacy questions were developed based on PISA (2015) framework, meanwhile technological and engineering literacy questions were developed based on NAEP (2014) framework. Environmental literacy comprises an awareness of and concern about the environment and its associated problems, as well as the knowledge, skills, and motivations to work toward solutions to current problems and the prevention of new ones. In this research, there are three aspects that build up students' environmental literacy which are environmental knowledge, environmental attitude, and environmental behavior. Sustainability literacy is described as knowledge, skills, and understanding required to pose a more sustainable future. It consisted of sustainability knowledge, sustainability attitudes, and sustainability behavior.

Objective test in the form of multiple choice, essay, and true or false questions were used to measure students' STEM literacy and environmental literacy knowledge. The objective test consisted of 24 questions. Furthermore,a questionnaire was used to assess students' environmental attitude and behavior, and sustainability knowledge, attitude, and behavior. The data was then calculated by using Ms.Excel, SPSS, and Winstep Rasch Model.

3. Students' Learning Style

Learning style refers to a person's learning preferences in apprehending, organizing, and processing information and learning experiences. The four learning style modes in VARK are visual (V), aural (A), read/write (R), and kinesthetic (K). Students with a visual preference learn best from a presentation of materials using graphs, charts, and diagrams; aural learners prefer to receive information through listening; read/write learners prefer to take in information through writing and reading from printed words; kinesthetic learners gain a better understanding of materials through concrete examples and applications.

Student's learning styles were assessed by using a multiple-choice questionnaire in which every choice represents one learning style. There are 16 questions in which the accumulative score of the learning style can be calculated to

determine the student's learning style. The data analysis was done by using Ms.Excel.

1.6 Organizational Structure of Research Paper

The structure of this research paper consists of five chapters:

1. Chapter I. Introduction. This chapter contains the background of the research, the research problem, the research objectives, the research benefits, the organizational structure of the research paper, and the limitation of the problems.
2. Chapter II. Literature Review. This chapter contains the literature review about virtual lab activity, inquiry-based learning, and the other variables, which are scientific literacy, attitude toward science, light, and optics, and relevant research.
3. Chapter III. Research Methodology. This chapter contains the method that is used to carries this research paper, which are research method and research design, population sample, operational definition, research instrument, instrument analysis, data collection, data analysis technique, research procedure, and research scheme.
4. Chapter IV. Result and Discussion. This chapter contains the result as well as the discussion and explanation about the result of this research paper.
5. Chapter V. Conclusion and Recommendation. This chapter contains the conclusion of the research paper, as well as the recommendation for future research.