



Sustainability Awareness, Engagement, and Perception of Indonesian High School Students during Sustainability Project Based Learning Implementation in Biology Education

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Abstract: This research aims to evaluate students' sustainability awareness and engagement and to analyze students' perception of the ESD Project in Biology lessons at an Indonesian Senior High School. This study uses a Mixed Method research design combining quantitative and qualitative research methods. The participants were Year X students of a Senior High School in Jakarta in the 2022/2023 academic year. Survey, journal of reflection, semi-structured interview, observations, and documentation, were used to collect data. Finding: This research found that ESD Project in biology lessons develops Indonesian students' sustainability awareness and engagement. Students change their mindset from being unconscious to become more concerned with environmental issues. Several evidence of the consciousness in this research includes applying sustainability in the daily practice, doing real action by creating campaign videos. The awareness is also shown by their beliefs, values, and judgments in their reflective journal, including developing environmental literacy, changing into pro-environment, and positive attitude to protect the environment. Secondly, PjBL learning model in Biology lessons is meaningful for students by stimulating their cognitive and behavioral engagement. The most popular activity of the ESD Project is creating the design of clothes from waste. The implementation of ESD Projects has some challenges such as time consuming, and low self-regulation among Indonesian high school students. Implications for research, practice, and policy are discussed.

Keywords: Biology education; Education for sustainable development (ESD), Perception; Project-based learning; Sustainability awareness

Introduction

Environmental issues such as pollution in metropolitan areas, domestic waste, climate change, and energy crises affect humans and the environment (Basri et al., 2021; Bergman, 2016). Indonesia suffers from pollution, global warming, and climate change. The primary contributing factor is the lifestyle of individuals not considering environmental sustainability due to a lack of environmental education and awareness (Bergman, 2016; Yuan et al., 2021). The solution to the issues is cultivating environmental awareness among the young generation in educational institutions (Krasny et al., 2010; Wilujeng et al., 2019). Knowledge of

environment and sustainability should be integrated for Senior high school students as the future generation. Students in Year X of Senior High School students in Indonesia learn Environmental topics in Biology lessons.

Indonesian Government, via the Ministry of Education, introduced the Merdeka Curriculum, which emphasized the importance of Project-Based Learning. Indonesian written curriculum of Biology Competence in Grade X is that students should be able to respond to global issues and play an active role in providing problem-solving in the form of simple projects using available technological applications. The knowledge and skills are related to alternative energy, global warming, environmental pollution, and utilization of waste and

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natural materials by the end of phase E (Indonesian Ministry of Education, 2022). These activities aim to reach the SDGs (sustainable development objectives).

UNESCO introduces Education for Sustainable Development (ESD) to raise environmental awareness among students (Korsager & Scheie, 2019; Müller et al., 2021). The ESD relies on three pillars to help students take responsibility and make decisions about environmental, economic, and social issues (Müller et al., 2021; Stagell et al., 2014; Walid & Luetz, 2018). Schools play a vital role in educating students about sustainability. Several studies highlight the value of environmental education in schools in raising students' sustainability awareness (Kalsoom et al., 2017; Kalsoom & Khanam, 2017; Korsager & Scheie, 2019; Olsson et al., 2019). Berglund et al. (2014) investigated the effect of implementing ESD in Sweden in terms of developing high school students' sustainability awareness (SC). The results showed significant differences in Sustainability consciousness between students from schools taught with the ESD approach and students from regular schools. However, ESD was mostly implemented in developed countries. Two countries that has outstanding performance of ESD implementation is Japan and Sweden (Fredriksson et al., 2020). The values of sustainability was also integrated in the curriculum in Qatar, Singapore and New Zealand (Fekih et al., 2021). Therefore, further research should be implemented in developing countries.

Biology education should integrate ESD because environmental science topics are related to biology in the everyday life of students. Indonesian High school students are expected to grasp the significance of biology in society and to be able to evaluate how their knowledge might help community sustainability and natural resource management (Paristiowati et al., 2022). Consequently, students must understand how to use the knowledge in their practice. Critical thinking, teamwork, communication, and creativity are required for 21st-century learning success. Students must be given a supporting process that promotes student-centered, active, and collaborative learning (Ekamilasari et al., 2021). One example of a student-centered model is project-based learning (PjBL), in which students learn to create their own learning experiences. Project Based Learning (PjBL) involves students applying theory, skills, and techniques to solve real-world problems (Bramwell-Lalor et al., 2020; Nation, 2008; Setyowati et al., 2022). PjBL is an inquiry-based instructional method that engages students in knowledge construction by asking them to complete meaningful projects and develop real-world products (Bramwell-Lalor et al., 2020; Genc, 2015). Project-based learning characteristics are it has a major project, a constructivist focus on essential knowledge and skills, activities that lead to

complex questions, problems, or challenges, investigations (Bell, 2010; Robinson, 2013).

Learning during PjBL integrated ESD in Biology lessons focuses on addressing environmental problems through a sequence of complex tasks while working cooperatively to generate realistic products or real actions (Bramwell-Lalor et al., 2020). PjBL requires students to use creative and critical thinking. There has been a shortage of research into how high school students understand sustainable development (Carew et al., 2002; Kagawa, 2007). There is a need to learn more about students' perceptions regarding sustainable projects in biology classes. A review of several previous studies shows that more than 70% of studies focus on PjBL in the university context, and quantitative is the most frequently adopted research approach (Al-Naqbi & Alshannag, 2018; Guo et al., 2020). Only a few studies reviewed the use of qualitative evidence and the role of PjBL in increasing students' sustainability awareness and engagement (Alsamani & Daif-Allah, 2016; Mohamadi, 2018).

Research investigating students' perception and challenges of ESD implementation during PjBL is also limited (Mitchell & Rogers, 2020; Paristiowati et al., 2022; Sagita et al., 2023). Meanwhile, knowledge on students' perception and obstacle of program implementation should also be considered in the future program (Ferrer-Estévez & Chalmeta, 2021). Based on the results of a systematic review of 25 articles, it was found that implementing ESD in the high school context is still needed in future research (Hoque et al., 2022), especially ESD project that emphasize on real action in bthe daily life (Chen & Liu, 2020).

According to the literature gaps, this research will answer two Research Questions, 1) How can implementing the ESD Project in biology lessons develop Indonesian High School students' sustainability awareness and engagement? 2) How do Indonesian high school students' perceptions and challenges during the ESD Project?

Method

Research Design

This study uses a Mixed Method research design. The Mixed Method method strategically integrates or combines quantitative and qualitative research methods (Mertens, 2016). This approach facilitates a more comprehensive understanding of the problem (Crowther & Lancaster, 2012; McNeill, 2006). Quantitative methods are carried out using self-administered surveys (Bryman, 2016; Friedrich et al., 2009; Watson, 1998). The survey was conducted to determine the sustainability consciousness and student perceptions. The source of data is self-administered

questionnaires as data collection instruments (Mertens, 2016; Nardi, 2018; Punch & Oancea, 2014).

This research also uses qualitative methods to understand concepts, opinions, or experiences of participants (Bryman, 2016; Patten & Newhart, 2017). The data collection method is a Reflective Journal, observation during learning activities, interviews, documentation of assignments, pictures, and observation sheets. A reflective journal describes written reflections in the students' essays regarding their learning experiences. Documentation was also made on student activities inside or outside the classroom (Punch & Oancea, 2014). An interpretive paradigm was employed to generate descriptions and explanations of the participants' interactions.

Participants

The participants in this study were Year X students of SMA Global Mandiri Jakarta in the 2022/2023 academic year using Merdeka Curriculum. A non-probability sampling or criterion-sampling method assessed their desire to engage in this study. The subjects voluntarily participated in this study and kept their identities private. The number of participants is 56 from 3 classes consisting of 27 male students (45%) and 29 female students (55%), which consisted of 3 classes.

Research Procedure

The research was conducted in three stages: preliminary, implementation, and final stage. In the early stages, the researcher conducted a preliminary study to identify the issues at the research location by observation. The researcher also did a literature review on how to implement Education for Sustainable Development (ESD) in Biology lessons. Then, the researcher created Teaching Modules, Modules of Projects as students' guidance and research instruments and validated the instruments. Before doing the research, it is required to acquire ethical approval from the Human Research Ethics, ensuring that the research adheres to research ethics standards such as informed consent and privacy. Potential volunteers are also given implicit information about the study's goal, the activity, and how long it will take. The steps of research procedure bis shown in Figure 1.

The implementation was conducted for 7 weeks, consisting of 3 x 45 minutes for each meeting. The PjBL in this research starts with determining the fundamental question, then developing project design, arranging a schedule, monitoring students and project progress, assessing the outcome, and evaluating experience (Bramwell-Lalor et al., 2020; Setyowati et al., 2022). Firstly, teachers inform students in the first week about the topics they will learn, the project they will do, the timeline to 4229ot he project, and the assessment method. Then, students were given material related to

environmental change, which included environmental issues, global warming, climate change, environmental pollution, management of waste, and renewable survei during weeks 1 to 3. During the third week of learning, students began doing group projects, from creating fashion designs, and creating campaign videos on sustainability-related issues. The SDGs that become the focus of this research are SDG15 (Life on Land), SDG13 (Climate Action), SDG6 (Clean Water and Sanitation), and SDG7 (Affordable and Clean Survei).

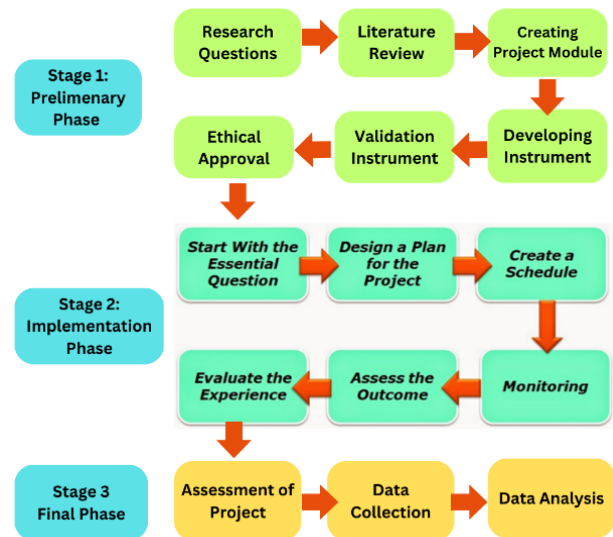


Figure 1. Research Procedure

The following description are the stages of group project (fashion design) implementation. Students are taught about group project-based learning. Students from three classes were separated into six groups of nine persons each, and they worked on project development activities to apply the 3R (Reuse, Reduce, and Recycle) to trash by creating clothing designs. Students cooperate in groups to divide roles, create work plans. Students are told about several garbage that can be used, the division of roles in groups, assessments, setting rules, and group member names. A project schedule is created to ensure task completion. The students were divided into six: the project manager, the primary designer, assistant designers 1 and 2, male and female models, garbage collectors, documentation, and the creative team. Each group's project implementation is led by a project manager.

Researchers also do observation and documentation to monitor the progress of their projects every week in a monitoring form. The assessment was completed at the meeting in week 8. Researchers assess the clothes of their group project with several criteria to know their creativity in the final product. We also collected survey data on sustainability practices, and journals of reflection. The student uses a Google form to write their thoughts, views, beliefs, and feelings about

the project implementation. Six random students are also interviewed from all classes. Students reflected on their overall impressions of the PjBL-based ESD implementation, the benefits, the challenges, and what they advised for future ESD in Biology lessons. The qualitative responses are coded and grouped based on the themes. The study team evaluated the student's awareness, perception, and engagement during and after the program according to the product of their project, observation of their daily habits, and self-reflection. The researcher then draws conclusions, and creates a research report in the last stage.

Instruments and Data Analysis

Journal of Reflection

A reflective journal was used to collect the participants' reflections on their overall learning experience, insight, sustainability awareness, soft skills, and the problems during the learning process. The questions of the reflections are: 1) Which project activity of sustainable lifestyle that you like most? 2) After doing the projects, what new knowledge do you learn? 2) How can the project develop your sustainability awareness? 3) How can the project develop your soft skills? 4) What are your difficulties and challenges during the Project? They could only select one response for their favorite activities. Other questions are open-ended responses. Students have forty minutes to complete the survey. Students' responses are analyzed with descriptive qualitative.

Semi-Structured Interview

A semi-structured interview was used to investigate students' engagement and perspectives about ESD and the project development and to complete data collection. The following are some examples of interview questions: "How about your engagement during sustainable lifestyle project in this semester?" "How do you feel about working, discussing, and collaborating with your classmates during the project? What is your challenges to do the project?" The result of recorded Interviews is transcribed and analyzed.

Survey of Students' Sustainable Lifestyle

The questionnaire employed in this study was self-administered online to determine the participants' sustainable lifestyles in their daily life. Researchers designed the Sustainability Practice Questionnaire research instrument by studying the sustainability practices of senior high school students by reviewing relevant peer-reviewed journals to identify the practice of sustainability that shows students' awareness. The researcher then developed a questionnaire that included four constructs: Global Warming Action, Water Consumption, 3R Waste Practice, and Energy Consumption. The frequency scale employs a five-point

scale from 1 to 5 (Never, Rarely, Occasionally, Frequently, and Always). The result of students' responses is analyzed with descriptive statistics.

Survey of Students' Evaluation Towards ESD Project in Biology Lesson

Students' evaluation of the ESD project was assessed using a survey developed by a previous researcher with modification (Sharma & Kelly, 2014). The purpose of the survey was to learn about students' views and perceptions of ESD related to developing their knowledge of environment, level of supportiveness, satisfaction, and usefulness of program (Table 1). The instrument comprised closed questions that collected quantitative data with a Likert scale of 1 to 5. Students' evaluation is categorized into Low ($X \leq 2.40$), Medium ($2.4 > X > 3.40$), and High ($X \geq 3.40$).

Observations and Documentation

Observations were conducted in this research to describe ESD implementation and Project-Based Learning that is acquired through observing and documenting students' activities during the program, images in every activity, and the participants' task assignments. A descriptive qualitative data-analysis technique was used. Observations and documentation data were used as evidence of participants' sustainability awareness, creativity, engagement, and collaboration during program implementation.

Result and Discussion

The Role of the ESD Project Integrated into Biology Lessons to Develop Students' Sustainability Awareness

ESD-Project-based learning is expected to improve sustainability competence, including knowledge, behavior, and attitude. This research found that ESD-based Projects integrated into Biology lessons can cultivate students' sustainability awareness by changing students' mindsets from being unconscious to becoming more concerned with environmental issues. Students' sustainability consciousness in this research can be seen from some evidence, including applying sustainability in their daily practice, doing real action by creating campaign videos, and reflective journals. An example of students' activities is shown in Figure 2.

The ESD practices to stop global warming include tree planting, reducing the use of products that contain CFCs, and using public transportation to travel. 3R Waste Practices, avoiding single-use plastics, using environmentally friendly products, separating waste, saving water and energy consumption. The Frequency of sustainable lifestyle practices among students during the ESD Program is shown in Figure 3. The result illustrates that saving energy is the activity that has the highest frequency in students' daily life, with average

rating of 4.02 in the high category. Two activities, including 3R waste practice and saving water, have a medium category with average scores of 3.46 and 3.19, respectively. While stop global warming action has the lowest frequency with an average frequency of 2.46. We found three activities that students rarely do in their daily life during the programs, including using public transportation and participating in the waste bank program, which has an average score lower than two. Therefore, Senior high school students mostly like more practical activities that are easy to do and do not need much effort.



Figure 2. Students' sustainability practices during ESD

Students' sustainability awareness is also shown by their willingness to spread action of sustainability by creating campaign videos on their social media. The topics of the students' campaign are very diverse such as reducing global warming, waste reduction, energy conservation, saving water. Some examples of students' activities in sustainability campaigns are shown in Figure 3.



Figure 3. Students' videos of sustainability campaigns on social media

The third evidence of students' awareness of sustainability during ESD in Biology lessons is their willingness to do actions such as organic composting waste and planting trees at school. The figure of students' activities is shown in Figure 4.

Table 1. Frequency of Sustainable Lifestyle Practices

Sustainable Lifestyle Practices	Average Frequency
Global Warming Action	
I take care of the plants at home	2.26
I reduce the use of products that contain CFCs	2.71
I use public transportation to travel.	1.98
I use bicycle or walk to get around	2.36
I inform others to be aware of global warming	2.55
3R Waste Practices	
I avoid using single-use plastics	3.40
I tend to send electronic messages than paper	4.49
I reuse water bottles and food containers.	3.91
I bring my own bag to shop at the market	4.12
I participate in the Waste Bank program	1.95
I separate recyclable and organic waste	3.05
Water Consumption	
I turn off tap water that are not used	4.42
I try to conserve water when washing	3.72
I speed up the shower time to save water.	2.93
I avoid use too much detergent	2.79
I reuse the rice wash water to water plants	2.11
Energy Consumption	
I turn off the light when not in use	4.18
I unplug the HP charger that is not used	3.63
I turn off the AC when not in use	4.14
I turn off the TV that I'm not watching	4.36



Figure 4. Students' activities in composting and planting

The last students' sustainability competencies during and after the PjBL in Biology lessons are described as beliefs, values, and judgments reflected in their journals. According to the reflective journal, Indonesian high school students show their awareness of the importance of caring for the environment. The

awareness includes developing environmental literacy (developing knowledge of global warming, environmental pollution, and waste management issues) and sustainability in their daily practice, to protect the environment (such as taking care of trees is very good for human life and the environment). The examples of students' self-reflection are listed in the following paragraphs.

"Before, I was not really concerned with Environmental issues. This biology lesson and project increased my knowledge of the environment by practicing a sustainable lifestyle in my daily life, such as 3R, reducing water and electricity usage." (Reflective Journal Participant 1).

"The project raised my awareness so I start to think about where I throw my trash. Also, I learned how to use energy inside my house and in public efficiently. I learned that Global Warming and water pollution causes a global crisis" (Reflective Journal of Participant 10).

According to the results, students have met the expectation of this project to cultivate the knowledge, values, beliefs, and practice from their experience that is applied in their daily life. The result of this study is supported by previous research. Several international studies related to environmental conservation projects show that the projects conducted in several countries develop students' environmental awareness. Several studies investigated several types of environmental actions such as improving polluted environmental conditions, planting trees for habitat restoration (Harder et al., 2014) by cleaning beaches, rivers, or school grounds, eliminating invasive plant species (Krasny et al., 2010), habitat protection and restoration, endemic wildlife, water quality, energi conservation (Baynham-Herd et al., 2018; Carleton-Hug & Hug, 2010).

Students' Engagement during PjBL and ESD Integration in Biology Lesson

PjBL learning model in the Biology lesson is meaningful for students by stimulating their cognitive and behavioral engagement. The PjBL model implemented in ESD of Biology lessons offers students with experience in group activities to solve the real problem of environmental issues. The list below illustrates some of the students' evidence of engagement, as shown by the result of interviews.

"I think this project is exciting because it increases the creativity of our brains. I felt challenged, maybe because it was my first time doing a design project. Also, after I learn the importance of planting." (Interview, Participant 1).

"It is fun to learn to do this project and enjoyable. We learn about reusing and recycling waste and the art of making the design. It's interesting if we learn in a fun way. In the future, I want to be an environmentally friendly fashion designer." (Interview of Participant 3).

The interview result shows that ESD-based projects in Biology lessons can stimulate students' engagement.

Student engagement refers to the level of attention, interest, optimism, curiosity, and passion displayed by students when learning or being taught, as well as their motivation to learn and succeed in their education. Student engagement is based on the belief that learning increases when students are inquisitive or interested. In contrast, learning suffers when students are bored, disinterested or disengaged (Paristiowati et al., 2022). The engagement was shown by some of the students' responses, such as the feeling that the project is fun by applying art in the design. PjBL also becomes their favorite learning activity than theoretical activities. Furthermore, PjBL improve students' interest in STEM career such as fashion designers in the future.

The role of PjBL in improving students' engagement is supported by previous similar research (Bédard et al., 2012; Morais et al., 2021; Robinson, 2013). The project improves students' engagement and interest in the environment. We found that stress during projects can affect students' engagement. Stress-related variables have become a major component of students' engagement and perseverance when evaluating such a program of learning tasks and activities. As educators, we should consider these when planning to assess the impact of stress on pupils (Bédard et al., 2012).

Students' Perceptions Towards ESD in Biology Lesson

Students' views towards ESD Program were analyzed through a survey and reflective journal. Reflective journals are a student-centered activity that allows for self-education that can inspire and motivate students who use them to reflect on prior experiences. The result of students' feedback on the ESD Program is shown in Table 1. Students have high level of Environmental Knowledge, supportiveness, satisfactory, usefulness, and the improved level of understanding of sustainability during the project. Most grade X students considered their knowledge of the environment such as global warming, water pollution, waste management, and renewable energy to be in the category of reasonable improvement. The typical scale rating score is 3.68. The average rating of students' understanding of sustainable development is 3.60 after the ESD program meaning that most students rate their understanding in the high category.

The result also shows that most participants give positive feedback on the ESD Project. Students think the ESD Project in Biology lesson is useful in their life and future, with an average rating of 3.66. Thirty-five of the 56 students rated 4 and above when asked about the project's usefulness. Many students think that learning about the environment and sustainability is important. The perception of students related to the usefulness of ESD project for their future career. In their evaluation survey, they were only rated medium category related to their supportiveness and satisfaction during the

project with a rating lower than 3.5. It means that the ESD project still needs to be improved. They rated a high category of supportiveness. Students also have high satisfaction with doing the group project.

Table 2. The result of Students' Feedback

Students Feedback	Average rating	Category
Knowledge of Environment	3.82	High
Supportiveness	3.46	High
Satisfactory	3.40	High
Usefulness	3.66	High
Understanding on Sustainability	3.60	High

Related to the usefulness, this research found that students argue that the Projects improve their 21st Century soft skills such as Creativity, Innovation, Collaboration, and Communication Skills as shown in their reflective journals and Interview.

"The project to create design can stimulate all of my designing skills, creativity, and innovation to finish. The individual project can develop my critical thinking skills through the Campaign Video" (Reflective Journal, Participant 9).

"The group project stimulates my communication skills by discussing the clothes design. Communication skills are important for my future. Regarding my collaboration skills, I can exchange ideas and opinions with like-minded people in my group from diverse backgrounds and characteristics." (Interview, Participant 2).



Figure 5. Students' project collaboration and creativity

PjBL stimulates students to think critically when they try to solve problems while designing clothes from recycled plastics. For example, they have to choose suitable plastics for new clothes. They also learn to practice their innovation when they make fabulous clothes with plastics without plagiarism on other designs. During the group project, students' creativity is trained by finding other ways to use the waste that is sometimes not working. To make their work stand out

from others' work, they have to use different techniques from other people, such as using different ways of thinking and having a distinct design style. This project-based learning encourages students to practice communication and collaboration. An example of students' creativity in their fashion design during the project is shown in Figure 5. Students use several types of garbage for their designs, such as plastic, newspapers, cardboard, and plastic bottles.

Students were also asked about the most popular activities during the ESD project in Biology lesson by choosing five main activities that they have done. The percentage of chosen popular activities during the ESD program is shown in Figure 6.

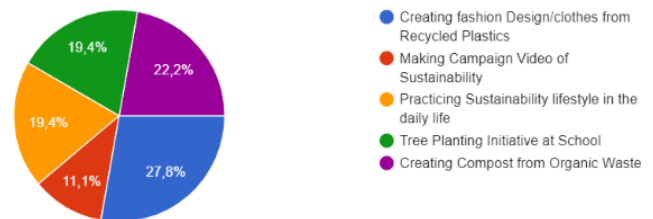


Figure 6. The percentage of popular activity during the ESD program in Biology lesson

According to Figure 6, creating fashion design from recycled plastics is the most popular activity of the ESD Project (27.8%), followed by creating compost from organic waste (22.2%). Practicing sustainability in daily life and planting trees have the same proportion of popular ESD activities (19.4%). However, making a campaign video has the lowest rating compared to other activities, which only 11.1%. A high proportion of students chose to create fashion design as their favorite because most students are more interested in group work than individual projects. Practicing sustainability in their daily life is also contextual, which has become their daily habit. In contrast, creating a campaign video is challenging because students need to think critically to influence other people.

PjBL and ESD have the same learning principles, including collaborative, contextual, experiential, problem orientation, and self-directed learning (Guerra, 2017). These learning principles provide the basis for implementing PjBL enabling the improvement of competence and knowledge of ESD. Students perceive project-based learning in environmental education as a useful approach that enhances creativity and encourages inquiry learning (Paristiowati et al., 2022). Project learning helps them define environmental problems more clearly and finding solutions (Genc, 2015). A similar study also found that students valued developing PjBL-related talents and skills such as group work, communication and leadership (Coronado et al., 2021).

Previous research found that project-based learning provided a second opportunity to improve cognitive skills easing their reintegration into society. It also demonstrates that project-based learning fosters the development of socio-affective abilities. Developing abilities such as persistence, willingness, cooperativeness, inventiveness, and initiative is dependent on and linked to learner's experiences, traits, needs, interests, and objectives (Koutrouba & Karageorgou, 2013). Sharing Ideas and Thinking Skills were substantially more valued by students during collaboration activities (Tongsakul et al., 2011).

Challenges or Obstacles of the Projects Implementation and Suggestions for Future Studies

Although students perceive that the project has some positive effects, this research found that students have negative views towards implementing the ESD program in Biology lessons. The quote of students' reflections related to their challenges or difficulties in doing the project is shown in the list.

"Talking obstacles regarding the individual project, there is not enough time to do the project. Our big challenge is the project turning the trash into clothes because it will be difficult to come up with ideas for students who are not creative." (Interview, Participant 3).

"The lack of guidance given by teachers makes it was little bit complicated. Also, in my opinion, it's hard for me to make video assignments and to make argumentation or opinions among friends" (Interview, Participant 8)

We found that there are three main obstacles to doing the project. Firstly, the projects are too many, so it should be reduced into one or two big projects. Secondly, Students argue that the time to do the project is quite short. Teachers should also monitor the progress of their work. PjBL relies on staff response to be confident in facilitating students' learning in an active learning environment (Kokotsaki et al., 2016; Mitchell & Rogers, 2020). Teachers need training and more information to implement PjBL in the classroom (Baghoussi & Zoubida El Ouchdi, 2019). Thirdly, students have lack of self-regulation which makes they encountered difficulties in collaborative activities. Students struggle with selecting priorities for their work and have poor self-control during PjBL (Russell et al., 2022). Students' ability to self-regulate is strongly related to their ability to organize, employ learning strategies Sagita et al. (2023), and evaluate activities that impact development in subsequent activities (Haataja et al., 2022; Kokotsaki et al., 2016).

Conclusion

ESD Project in biology lessons develops Indonesian students' sustainability awareness and engagement. Students change their mindset from being unconscious

to become more concerned with environmental issues. Several evidence of the consciousness in this research includes applying sustainability in the daily practice, doing real action by creating campaign videos. The awareness is also shown by their beliefs, values, and judgments in their reflective journal, including developing environmental literacy, changing into pro-environment, and positive attitude to protect the environment. Secondly, PjBL learning model in Biology lessons is meaningful for students by stimulating their cognitive and behavioral engagement. The most popular activity of the ESD Project is creating the design of clothes from waste. The implementation of ESD Projects has some challenges such as time consuming, and low self-regulation among Indonesian high school students. The limitation of this study is that researchers examined students' sustainability consciousness qualitatively, which means that the awareness was dependent on participant honesty during self-reflection or interview. As a result, future studies can employ quantitative surveys, to assess students' awareness. Also, the research of ESD should be conducted in other developing countries to investigate cultural differences. This study has consequences for research, policy, and practice. The findings and design of this study can be used as an inspiration for stakeholders in schools and the Indonesian government, via the Ministry of Education, for ESD implementation in Senior High Schools. The outcomes of this study can be used to evaluate the projects design in Biology for high school student.

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Author Contributions

Heru Setiawan: writing—original draft preparation, result, discussion; Hertien Koosbandiah Surtikanti: validation, methodology, analysis, proofreading, and editing; Kusnadi, Riandi: supervision, conclusion, and review.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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