RESEARCH ARTICLE

Gender differences and the correlation of environmental knowledge with sustainability awareness after ESD-PjBL implementation

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Abstract: Students' environmental knowledge and sustainability awareness are important competencies to prepare them to face global environmental challenges. The study aimed to evaluate the gender difference and correlation between students' environmental knowledge, sustainability awareness, and sustainability practice frequency after Education for Sustainable Development (ESD) in Biology lesson. This study uses a quantitative research design with a one-group pretest posttest design using cognitive tests and a self-administered survey. The participants were year X students in one of the schools in Indonesia, during 2022/2023 academic year, including 114 students (M=54, F=60). The result found that although Indonesian high school students generally have high overall environmental knowledge students have low knowledge of global warming. Students have a high sustainability awareness and a high average frequency of practicing sustainability. Secondly, this research found that gender differences exist where female has significantly higher environmental knowledge than male students. Female students also have higher consciousness in all specific domains of sustainability, and they have statistically higher sustainability behavior than males. Environmental knowledge has a statistically moderately positive correlation with the frequency of sustainability practices. Environmental knowledge has a weak correlation with sustainability awareness. The frequency of sustainability practices has low correlation with sustainability awareness.

Keywords: Education for Sustainable Development (ESD); environmental knowledge; gender difference; Indonesian high school; sustainability awareness

Introduction

Environmental issues such as pollution in urban areas, climate change, domestic waste problems, and the energy crisis concern humans and the environment (Christensen & Knezek, 2015; Whitburn et al., 2019). Indonesia also has high environmental pollution, especially in urban areas. The annual landfill rate in Indonesia is 64 million tons, dominated by 60% organic waste, 14% plastic, and 9% paper. The main contributing factor is the lifestyle of people less concerned about environmental sustainability caused by low environmental knowledge and awareness of sustainability (Salehi et al., 2015; Tobler et al., 2012). Environmental knowledge is an indicator of environmental literacy, which refers to the comprehensive quality of knowledge that people have about the environment or an individual's understanding of the aspects that build the environment and the principles that occur in it in maintaining environmental quality (McBride et al., 2013; Gheith, 2019). Students who are environmentally knowledgeable will have knowledge related to facts, concepts, or relationships regarding the surrounding

environment and its ecosystem. Environmental knowledge can also be seen in more general terms, such as awareness about the use of environmentally friendly products, or in more specific terms, such as issues related to recycling or carbon programs. Environmental knowledge is an indicator of environmental literacy in the cognitive aspect. environmental literacy indicators consist of ecological knowledge, cognitive skills, environmental consciousness attitudes, and environmentally responsible behavior which can significantly influence environmental attitudes and behavior (Negev et al., 2008). Environmental knowledge in this study is related to biology, such as global warming, climate change, environmental pollution, waste management, and renewable energy.

On the other hand, students who have sustainability awareness have experience or awareness of sustainability phenomena (Raymundo et al., 2019). This includes the experiences and perceptions we usually associate with ourselves, such as beliefs, feelings, and actions. The dimension of sustainability consciousness includes knowingness, attitudes, behavior, in three dimensions (economy, social, environment) (Gericke et al., 2019). Sustainability practices are practices to implement sustainability in everyday life (Velázquez et al., 2006). Many sustainability practices can be implemented by students in school or at home as real actions for students to implement and realize the goals of SGDs in daily life (Mahat et al., 2017). The SDGs that become the focus of this research are SDG6 (Clean Water and Sanitation), SDG7 (Affordable and Clean Energy), SDG13 (Climate Action), and SDG15 (Life on Land). Increasing students' environmental knowledge and sustainability awareness, and practice can be improved in schools through the Education for Sustainable Development (ESD) (Setyowati et al., 2022). ESD is an education program to create a sustainable future in realizing Sustainable Development Goals (SDGs) by cultivating knowledge, attitudes, and values relevant to economic, social, and environmental (Fraisl et al., 2020; Kroll et al., 2019). Schools and universities are important in teaching students about sustainability (Kioupi & Voulvoulis, 2019). Several studies support the importance of environmental education in schools in developing students' sustainability awareness (Brick & Lewis, 2016; Carmi et al., 2015; Prati et al., 2017).

The implementation of ESD in Indonesia, especially in the context of secondary schools, is still limited compared to the implementation in developed countries. Two countries that have had an outstanding performance in implementing ESD in secondary schools are Japan and Sweden (Fredriksson et al., 2020). Meanwhile, the implementation of ESD in Indonesia is still limited and only focuses on and emphasizes content rather than taking real action to preserve the environment (Eliyawati et al., 2022). Therefore, further research on ESD implementation is needed in Indonesia. This research was conducted in one of the schools in Jakarta Province. Jakarta was chosen because one of the provinces with an alarming pollution level and ranks 4th as the most polluted city. However, the material presented in the Merdeka curriculum shows that sustainable development is minimal because it only contains basic material without a project for real action (Eliyawati et al., 2022).

The Ministry of Education of Indonesia implements the Merdeka curriculum that includes the SDGs as the goal of learning outcomes of Natural Sciences in grade X of Secondary School. According to the written curriculum, at the end of phase E, students must have the ability to be responsive to global issues and play an active role in problem-solving related to alternative energy, global warming, environmental pollution, utilization of waste and natural materials. These efforts are directed to achieve sustainable development goals (SDGs). This research is significant for research, practice, policy, and social action. Theoretically, this research can be used as a reference for further research on developing ESD programs in Biology education considering the role of gender in influencing students' awareness of sustainability. Also, the result of this study can be used as a reference for the role of environmental knowledge as a predictor of sustainability awareness and practice. This research practically contributes to teachers and schools. For teachers and schools, this research can be used as a reference for designing ESD programs considering gender differences. For social action, this research can be used as a reference for real action activities on individual or group projects in preventing environmental damage implemented in schools, for example, by providing opportunities for students to be directly involved in both practical activities and direct experience.

There are some gaps in the existed literature. Most ESD research was conducted in developed countries such as the USA, Germany, Norway, and Japan (Müller et al., 2021). Limited research is conducted in developing countries such as Indonesia and South East Asia. Meanwhile, cultural differences between students from emerging and developed nations due to external variables (educational curriculum, culture, environmental systems, and services in each country) affect students' environmental practices and behavior. In addition, most of the current research is conducted at the university level (Al-Naqbi & Alshannag, 2018; Janmaimool & Khajohnmanee, 2019). Therefore, further research needs to focus on ESD at the senior high school level in developing countries such as Indonesia. Although Level of sustainability awareness research has been conducted in Indonesia, most are in the Physics context (Ridwan et al., 2021). Therefore, comprehensive research should be conducted in the biology education context, especially on the topics of global warming and environmental pollution. In addition, pro-environmental attitudes are also influenced by many complex factors such as level of education, age, and gender (Bronfman et al., 2015). However, the conclusions of several researchers about the relationship between gender and students' environmental knowledge, behavior, and practices are still

limited and inconsistent in the literature. In addition, there is limited research in Indonesia correlating students' environmental knowledge, sustainability awareness, and sustainability practices. Meanwhile, investigating factors that can predict the sustainability factors is important. According to the gaps in the literature, this article aims to evaluate the gender difference and correlation between Indonesian high school students' environmental knowledge, sustainability awareness, and practice after ESD in Biology lesson.

Method

Research design

This study uses quantitative research using cognitive tests and self-administered surveys. The research design used in this study is a one-group pretest posttest design. The dependent variable is measured before and after the treatment of ESD-based learning is implemented in Biology lessons. The final test of environmental knowledge and questionnaire to measure students' sustainability awareness was given after the treatment. The cognitive test of environmental knowledge uses multiple-choice test questions to determine the score of environmental knowledge. The survey was conducted to determine the sustainability consciousness and practice.

Participants, location, and time

The participants in this study were all grade X students of SMA Global Mandiri Jakarta in the 2022/2023 academic year. Grade 10 was chosen because it is a class that uses the new Indonesian curriculum of Merdeka. The school is chosen because based on the results of preliminary research at SMA Global Mandiri Jakarta, only 60% of students stated that they had a caring attitude towards the environment at school, and only 15% of students knew about the 17 SDGs agenda related to climate change, waste management, and clean water sanitation. Although the majority of students always throw rubbish in the trash and separate organic and inorganic waste (90%), there are still very few who reuse and recycle plastic waste at school (23%). Based on the results of the interviews, the school had not implemented a program designed to increase environmental care and sustainability awareness among students. Biology teachers also have no projects to students to do 3R (reuse, reduce, and recycle) or concrete actions to prevent global warming, manage waste properly, and save water and energy at school. Based on the results of this preliminary research, the researchers designed an Education for Sustainable Development (ESD) program that was integrated through project (PjBL) activities in biology lessons. All students were selected because the total number of students was only 114 from 5 classes consisting of 54 male students (47.3%) and 60 female students (52.6%). The average age of students is 14 - 16 years. In addition, the school is a school that applies the Sustainable Lifestyle theme in Projek Penguatan Profil Pelajar Pancasila (P5). The time for conducting the research is in the 2022/2023 academic year, from January 2023 to March 2023.

Research procedure

The research implementation was divided into 3 stages, including the initial stage, the implementation stage, and the final stage. Firstly. In the early stages, researcher prepared students' learning material, such as Teaching Modules and research instruments. Instrument validation was also conducted to test the validity and reliability of the instrument. In addition, ethical approval was obtained from the Human Research Ethics of Universitas Pendidikan Indonesia, ensuring that the research follows the principles of research ethics. Potential participants are also provided with information implicitly regarding the research. Secondly, the researcher delivers the integrated biology lesson with ESD at the implementation stage by providing a learning module. Biology lesson was conducted for 3 hours of lessons or equivalent to 3 X 45 minutes each week. In the first week, students were given the material on environmental change, which included global warming and climate change. In the second and third weeks, students are given the material on ecosystem and water pollution. While at the fourth meeting, the material presented was about 3R waste management. In this meeting, teachers inform students about sustainability practices. Students are given worksheets to record how often they do 20 sustainable lifestyle practices daily for 3 weeks to know the average frequency.

During week 3, students were also informed about individual and group projects. The group project is to create fashion designs from inorganic waste materials. In addition, students are invited to take two real actions on sustainability in the fourth week, including the tree planting program (a tree planting program as an effort to prevent global warming) and take real action by making a video campaign on social media related to sustainability. Group and individual projects are carried out in the fifth to eighth weeks. Videos that students have made are uploaded to Instagram. All students must watch all the sustainability campaign videos made by other students on Instagram. The topics of the campaign are Stop Deforestation and Illegal Logging to prevent Global Warming, Reducing energy consumption at home to

protect the environment, Reducing water consumption for water sustainability, Using Public Transport and reduce the private vehicle to reduce fossil Fuel Emission, Sustainable Lifestyle by Save Electricity and Energy efficiency, Tree Planting and Gardening as an effort to stop Climate Change, Using Environmentally Friendly Product, and Waste Bank to Support Indonesia Clean-from-Waste.

The final phase was including reflection of learning, and the Assessment that was conducted at the 8th-week meeting. The researcher conducted a posttest at this meeting to determine the students' environmental knowledge. The students are given 90 minutes to answer 20 questions of environmental knowledge by pencil and paper test. In addition, researchers also collected survey data on sustainability awareness and sustainability practices after the test. The students complete the surveys online using a Google form. Google Forms is used because it is an easy platform for data collection and data analysis. They could only choose one response for each item. Forty minutes are given to students to complete the survey. After that, in the final stage, the researcher analyzes the data, draws conclusions, and make a research report. The flowchart of research steps is shown in Figure 1.

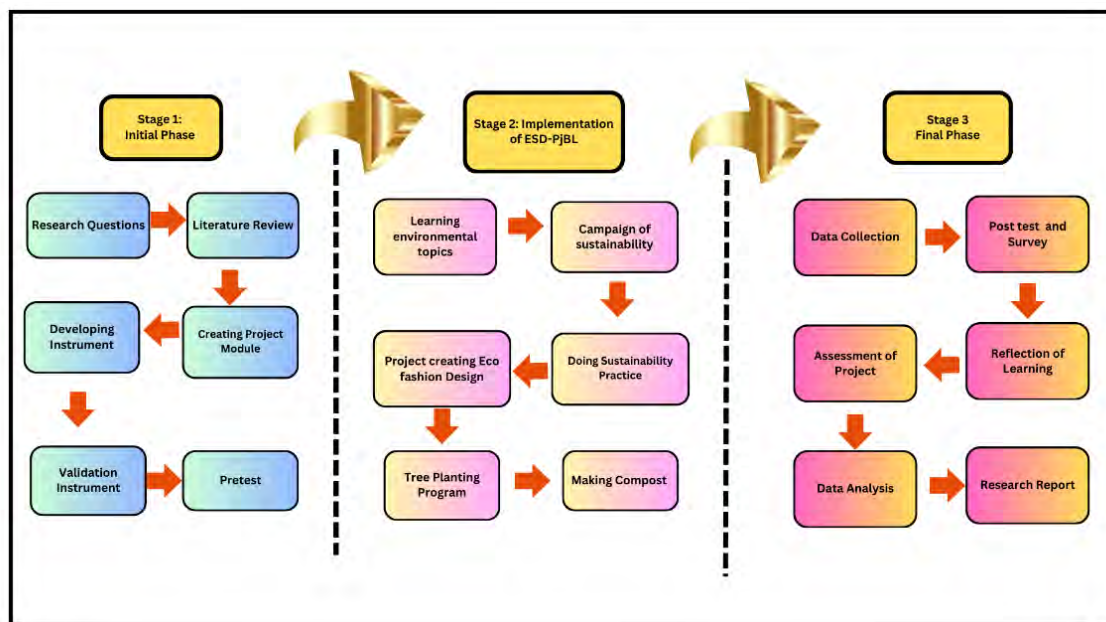Figure 1. The flowchart of research procedure

Research instruments

The instrument used to measure students' environmental knowledge was initially developed by researchers, including 24 multiple-choice questions. The environmental knowledge test instruments include four sustainability topics (Knowledge of Global warming and Climate Change, Knowledge of 3R Waste Management, Water Pollution, and Knowledge of Renewable Energy). The questions developed are then tested first to determine the validity and reliability of the instrument. According to the validity of the items, only 20 valid questions are remaining that are used in the post-test, where each topic consists of 5 questions. The results of the reliability = 0.57 which is reliable.

The instrument to measure student sustainability awareness data is a survey instrument adapted from the previous research (Gericke et al., 2019) originally used the term sustainability consciousness. The instrument was translated into Bahasa Indonesia. The instrument contains 27 statement items which are divided into 3 indicators, including Knowingness (K), Attitude (A), and Behavior (B), and three dimensions, namely environmental, social, and economy. The questionnaire instrument uses 4 points Likert scale, including strongly agree, agree, disagree, and strongly disagree. The result of confirmatory factor analyses shows a good fit with Root mean square error of approximation (RMSEA)= 0.052; Comparative fit index (CFI)=0.867; Tucker-Lewis Index (TLI) =0.850). The sustainability awareness test instrument was retested by the researcher for the validity and reliability of the items. Based on the validation results, all items are valid with a significance value of all items > 0.5 and a reliability value of 0.887, which is satisfactory.

The research instrument for the Sustainability Practice Questionnaire was developed by researchers (Setiawan et al., 2023). The questionnaire consisting of four constructs, namely Global Warming Action (GWA), 3R Waste Practice (RWP), Water Consumption (WC), and Energy Consumption (EC). The frequency scale uses a five-point scale from 1 to 5 (Never, Rarely, Sometimes, Often, and Always). The factor loading of all items is higher than 0.5, meaning that the variables are relevant in explaining a

construct. Bartlett's test of sphericity was significant (p<0.001), and the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was 0.665, indicating that the data were suitable for factor analysis. Valid and reliable SPF instrument results were then used for the survey.

Data analysis

Descriptive statistics are used in this study to describe the level of environmental knowledge level, sustainability consciousness, and sustainability practices based on gender. For the sustainability awareness and student perception questionnaires, each statement item has four alternative answers with a score for each item between 1-4, including: strongly agree (4), agree (3), disagree (2), and strongly disagree (1). As for the frequency of sustainability practice, there are five alternatives for each statement item, including always (5), often (4), sometimes (3), rarely (2), and never (1). The level of knowledge of students is categorized into two categories, low category (Average Score <2) and high category (Average Score >2) for each topic (Knowledge of Global warming and Climate Change, Knowledge of 3R Waste Management, Knowledge of Water Pollution, and Knowledge of Renewable Energy). The sustainability Awareness Score is categorized into two categories, including low (Average Score ≤2.90) and high (Average Score ≥2.90). Sustainability Practice Frequency is categorized into 3 categories including Low (Average Score ≤2.40), Medium (Average Score between 2.4 and 3.40), and High (Average Score ≥ 3.40). The data is then arranged in tabulations and bar charts in Microsoft Excell. Descriptive statistics also present average, percentage, and standard deviation data

Then, the t-test is used to test whether environmental knowledge, sustainability awareness, and sustainability practices are statistically different according to gender.. Second, the Pearson correlation check is used to analyze whether there is a correlation between Gender. Correlation analysis is presented in the scatterplot. Pearson's r, p-value, and effect size are important for determining correlation (Bryman, 2016). Spearman's rank correlation coefficient (r) was calculated using Microsoft Excel to see a linear trend. It is presented in a scatter plot graph to see the trends (Setiawan & Phillipson, 2020). The direction of the correlation can be positive, negative, or no correlation (Mertens, 2016). The p-value indicates whether the relationship found in the correlation coefficient is statistically significant. When p < 0.05, the relationship is statistically significant.

Results and Discussion

Students' environmental knowledge and sustainability awareness during ESD-PjBL

The first aim of this research is to analyze the influence of ESD to students' environmental knowledge. Environmental knowledge in this research is students' understanding of four environmental subtopics, including global warming, environmental pollution, waste management, and ecosystem. The learning objective is that students are able to analyze data including the causes and impacts of environmental change and environmental pollution in the daily life. The level of environmental knowledge that students have can influence them to make appropriate environmental choices and act more responsibly towards the environment. The environmental concepts include 20 questions consisting of five questions each on the topics of global warming, environmental pollution, waste management, and ecosystems. The results of the hypothesis test show a significance figure of <0.05, which means that there is a significant average increase between the results of the pretest and posttest scores for students' environmental knowledge. The average pretest score is 42.22, and the average posttest score is 80.56. The average posttest score is higher than the pretest score which shows an increase in the average environmental knowledge after the ESD-PjBL implementation.

Overall, the results of the students' environmental knowledge showed an increase from pretest to posttest with N-Gain of 0.66, or in the medium category. It means that the implementation of ESD-PJBL in biology lesson is considered quite effective in increasing students' environmental knowledge. The highest N-gain value is in students' knowledge of ecosystem material, with an N-gain of 0.80. Meanwhile, the lowest N-Gain is in the topic of global warming, with an N-Gain of 0.62. The pretest and posttest graphs for students' environmental knowledge are presented in Figure 2. The highest average pretest and posttest scores were in the knowledge of ecosystem, with an average pretest score of 55 and a posttest score of 91. Meanwhile, the lowest average score was in knowledge of global warming, with an average pretest score of 31 and a posttest score of 74. Therefore, the implementation of ESD-PjBL can increase the average score of high school students' environmental knowledge.

This research also aims to determine the effect of ESD-PjBL in biology lessons on high school students' sustainability awareness. The result shows that students' sustainability awareness scores showed an increase after the integration of ESD-PjBL. An increase in students' overall sustainability awareness score was 4.88. The score of the pretest was high, with an average score above 75. This means that students have a high level of understanding of sustainable development issues. The increase in average

differences was due to the learning process, which was related to environmental problems. The sustainability awareness measured in students in this research consists of three aspects, including sustainability knowingness, sustainability attitude, and sustainability behavior. However, based on the results of the hypothesis test, it shows a significance figure greater than 0.05, which means that there is no significant difference or increase in the average between the results of the initial score and the final score of students' sustainability awareness. The highest N-gain value is in the knowledge aspect (sustainability knowingness), with an N-gain of 0.31. Meanwhile, the lowest N-Gain is behavioral aspect (sustainability behavior), with an N-Gain of 0.18. The difference in average sustainability awareness scores can be seen in Figure 3. Overall, the initial score to the final score of students' sustainability awareness show an increase with N-Gain of 0.23 or low category. Therefore, ESD-PJBL in biology learning can increase students' sustainability awareness, even though the increase is not significant. In addition, most students (88.6%) had high awareness after participating in the ESD program.
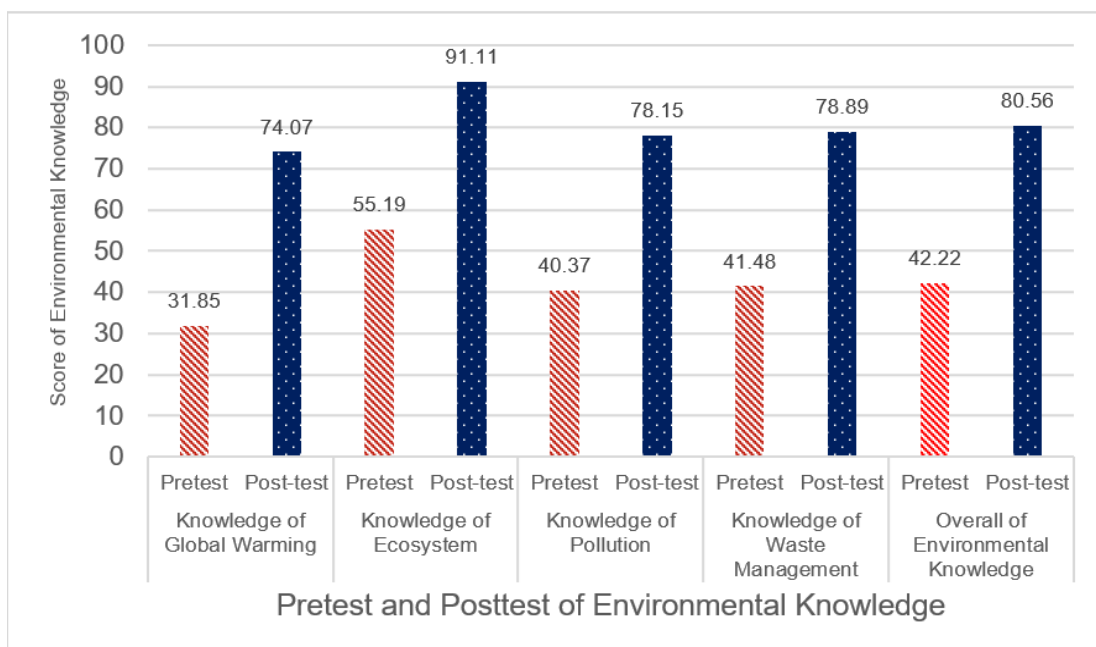

Figure 2. Results of students' pretest and posttest scores of environmental knowledges
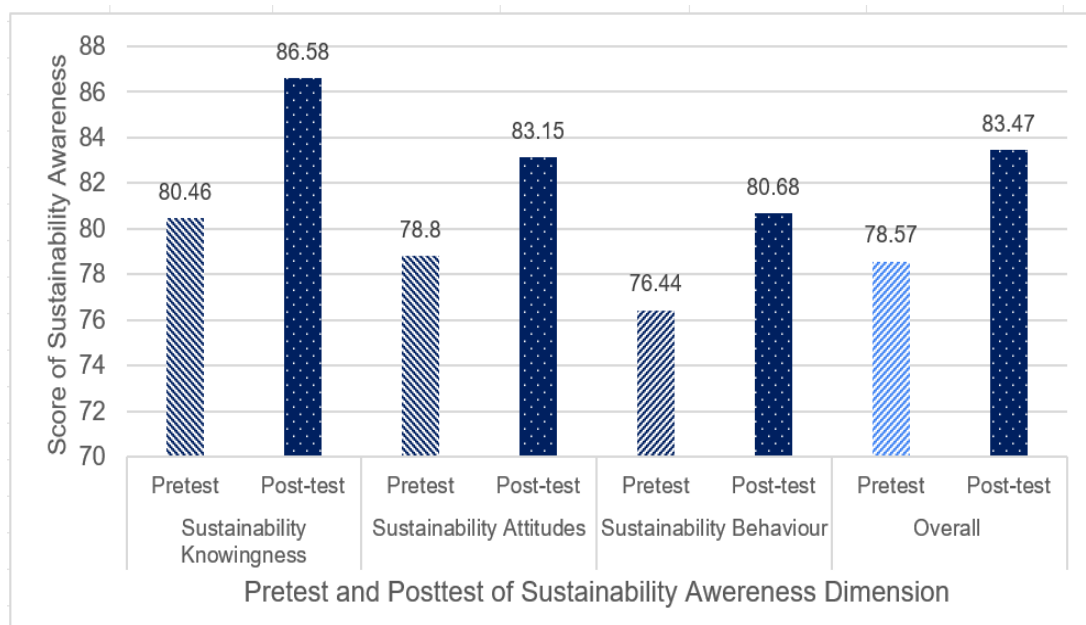

Figure 3. Pretest and posttest of sustainability awareness scores

After the implementation of ESD, Indonesian senior high school students' average scores of environmental biology topics were generally high in ecosystem, waste management, water pollution although most of the students had low average knowledge of global warming. This result means that Indonesian students perceive that those three topics are easier than global warming. The result of this research is supported by previous research using Diagnostic tests found that 51.7% of Indonesian students have a misconception about global warming, the greenhouse effect, and ozone layer depletion, whereas 37.7% of students believe they comprehend the concept and 11% have a mistake. Similar results were also found in other countries, such as Iran (Yazdanparast et al., 2013), and Malaysia (Karpudewan et al., 2015). Misconceptions arise due to knowledge obtained by students from erroneous source (Arslan et al., 2012). Based on the findings, we recommend that process-based learning should be used to provide learning that prioritizes the process so that the information can be accepted by students. The high average score of environmental knowledge is also due to the lesson module creating by the teachers which is shown in Figure 4.

Secondly, Indonesian students also have a high perceived level of sustainability awareness, including sustainability knowingness, attitude, and behavior after implementing the ESD program. Sustainability includes three main aspects: economy, environment, and society. That is, development is only sustainable if it has adequately addressed issues related to economic feasibility, social justice, and environmental impacts (Agbedahin, 2019; Winkler et al., 2019). This research differs from similar research in the UK, where many UK students have a low frequency of saving electricity and recycling paper, possibly indicating that young people in the UK feel disempowered regarding this issue. The high consciousness and high average frequency of practicing sustainability of Indonesian students is also because, at the same time, the Indonesian curriculum implements Projek Penguatan Profil Pelajar Pancasila (P5) with one of the themes is Sustainable lifestyle that is implemented in the high school for approximately four months in Semester two. Therefore, the ESD is integrated into Biology lessons in this research and is supported by the program with the same mission to cultivate a sustainable lifestyle among Students. Several studies in other countries supported the importance of environmental education in schools in developing environmental care attitudes toward students (Brick & Lewis, 2016; Carmi et al., 2015; Janmaimool & Khajohnmanee, 2019). School programs and school policies affect students who are in schools that implement environmental policies (Duarte et al., 2017).

Figure 4. The design of learning module of Environmental biology integrated ESD-PjBL

The high level of students' sustainability awareness of this research contradicts some literature arguing that students living in the city tend to have lower awareness than students living in the village (Mahat et al., 2017). This condition is due to the higher exposure to the environment experienced by students in this research in a private school, mostly living in Jakarta Garden City that practices sustainable and green housing. For example, the housing has many plants, good access to public transportation such as the MRT or Commuter line, good management of waste, and water sanitation. Therefore, the environment of students may contribute to the practice of sustainability in their daily life as well. The low level of some items in sustainability practice of students is that some practices of Sustainability are quite challenging to implement in daily life, such as informing other people of the effect of global warming and avoiding using plastic bags. Similar research in Indonesia supported that discussing sustainability and composting organic waste are quite difficult to implement for students (Ridwan et al., 2021).

Gender difference in students' environmental knowledge, level of sustainability awareness, and sustainability practice frequency

According to Table 1, Female students has statistically significantly higher environmental knowledge than male students (p<0.05) related to Ecosystem. The female also has a higher knowledge of global warming and pollution, but it is not statistically significant. In contrast, male students have statistically significantly higher knowledge of waste management than female students (p<0.05).

Table 1. Students' environmental knowledge according to gender

Environmental Knowledge	Gender	Mean	SD	t-value and level of significance
Knowledge of Global Warming	Male (N=54)	69	1.02	0.16
	Female (N=60)	70	0.87	
Knowledge of Ecosystem	Male (N=54)	87	0.77	2.40 *
	Female (N=60)	97	0.95	
Knowledge of Water Pollution	Male (N=54)	77	1.12	1.87
	Female (N=60)	87	1.30	
Knowledge of Waste Management	Male (N=54)	82	1.02	2.62 *
	Female (N=60)	73	1.00	

* Significance at p<0.05

According to Table 2, we found that both male and female students have a high category of sustainability consciousness in all domains with the average mean above 75. Generally, female students rated higher on all aspects of Sustainability consciousness and in all specific domains of sustainability, including environmental, social, and economic factors. The results in Table 3 show that there were gender differences in the scales of sustainability behavior. The female has a statistically significantly higher level of sustainability behavior than the male (p<0.05). In addition, they also have a higher level of knowingness, and attitudes than male students, although the difference is not statistically significant.

Table 2. Students' level of sustainability awareness according to gender

Sustainability Awareness Domain	Gender	Mean	SD	t-value and level of significance
Sustainability Knowingness	Male (N=54)	87	0.50	0.96
	Female (N=60)	91	0.36	
Sustainability Attitudes	Male (N=54)	83	0.40	1.13
	Female (N=60)	85	0.39	
Sustainability Behavior	Male (N=54)	81	0.43	1.75*
	Female (N=60)	85	0.48	

* Significance at p<0.05

This study also analyze gender difference on students' sustainability practice in the daily life (Table 3). Based on gender, female students rated higher average frequency on sustainability practice in two aspects, including 3R waste practice and energy consumption. For example, females are more often than male students to reuse water bottles and food containers, bring their bags for shopping at the market, turn off the bedroom light when not in use, and turn off the TV that is not watching anymore. In contrast, although the difference is not statistically significant, male students have a higher average frequency of sustainability practice in the other two aspects, including global warming action and water consumption. For instance, male students are generally more frequently in using public transportation to travel, using bicycles to go around, conserving water when washing, speeding up the shower time.

This study discovered that female students have a greater environmental understanding than male students regarding ecosystem, global warming, and water pollution. Male students, on the other hand, have a statistically much greater understanding of waste management and its applications than female students. This study's result differs from a study in the USA, where women convey greater scientific knowledge of climate change than men (McCright, 2010). Therefore, the result of this research contradicts existing sociology of science research that women underestimate their climate change knowledge more than men. Previous research supported that male student, especially those studying Engineering, Social and Human Sciences, have higher levels of environmental understanding (Paço & Lavrador, 2017).

Table 3. Sustainability practice frequency of students according to gender

Domain	Gender	Mean	SD	t-value and level of significance
Global Warming Action	Male (N=54)	48	0.70	0.22
	Female (N=60)	47	0.62	
3R Waste Practice	Male (N=54)	68	0.73	0.37*
	Female (N=60)	71	0.62	
Water Consumption	Male (N=54)	70	0.92	0.23
	Female (N=60)	69	0.80	
Energy Consumption	Male (N=54)	80	0.90	0.06
	Female (N=60)	83	0.70	

* Significance at $p < 0.05$

Female students evaluated greater average frequency on sustainability practice in two categories, 3R waste practice, and energy use, based on gender. Some literature supported the result of this research that women tend to be more environmentally oriented than men significantly (Xiao & McCright, 2015). Female students appear more conscious of sustainability (Paço & Lavrador, 2017). Women show stronger pro-environmental attitudes and behavior than men and a higher level of socialization and social responsibility. In addition, other studies have shown that women report more pro-environmental actions when asked about everyday behaviors such as energy conservation, recycling, water conservation, and transportation use (Carleton-Hug & Hug, 2010). Women are more active only in one particular domain of pro-environmental action related to consumer behavior (buying organic products, reducing vehicle use, sorting out recycling) in the private sphere, but not in other spaces related to the public, the scope (environmental group membership and signing of petitions, for example, are considered to be more male-dominated). Within this framework, women are directed to roles that encourage them to be more compassionate, empathetic, and cooperative than men, thus, more protective of nature. However, men emphasize the role of economic providers and market activities, encouraging men to be more masterful, rational, and competitive than women and, therefore, closer to anti-environmental attitudes (Hunter et al., 2004; Tobler et al., 2012).

This research also found that male students had a greater average frequency of sustainability practice in the other two areas, which include global warming action and water usage. Some literature supports that males may have a higher level of sustainability consciousness depending on the aspects. Men's environmental attitudes are higher than women's, so men tend to be more sensitive to programs that try to change their behavior (Vicente-Molina et al., 2013). The gender differences found here only affect the use of public transport, which is more likely to be used by male students in this research. Notably, some items they are not following the same pattern. For example, for global warming action, females are more often to take care of the plants at home (planting or watering plants) and inform others to be aware of the negative impacts of global warming. Males often avoid using single-use plastics such as plastic straws and styrofoam in 3R waste practice. The similar level of sustainability awareness between males and females in some items because students have the same perception. Therefore, the stereotyped gender role of women does not fully function for everyday pro-environmental actions that are traditionally considered within the scope of domestic work and are usually associated with women (Xiao & McCright, 2015).

The idea that women are "closer to nature", caring for the land, water, forests, and other aspects of the environment, has held strong way in development theory since the 1980s, drawing on a range of ecofeminist analyses, from feminine principles to ecospiritualist orientations. Feminism is the ultimate solution to the world's ecological and social problems. Environmental justice is gendered because women suffer the most from poverty, human rights violations, and environmental destruction. Climate change disproportionately affects women due to the combined feminization of poverty and environmental degradation caused by climate change, while their adaptive capacity is limited by the exclusion of their needs and perspectives from climate change (Sakellari & Skanavis, 2013). This is also supported by Future models of environmentalism will include gender as a relevant predictor of environmentalism.

The correlation between students' environmental knowledge, level of sustainability awareness, and sustainability practice frequency

This research analyzes the correlation between the variable's environmental knowledge, sustainability awareness, and frequency of students' sustainability practices during the implementation of ESD-PjBL in biology learning. All correlated variable scores, including environmental knowledge, sustainability awareness, and sustainability practices, are converted to a scale of 100. Correlation analysis is used to determine whether there is a linear relationship between two variables shown in the correlation coefficient. The correlation coefficient is a value that shows the strength or weakness of the linear relationship between two variables. The correlation coefficient is usually denoted by the letter r, where

the value of r can vary from -1 to +1. The results of the regression analysis are presented in a scatter plot graph. A scatter plot is a distribution of points based on the values of variables X and Y. From the scatter plot display, it can be seen whether there is a tendency for a linear relationship between the two variables. The coefficient of determination, or R squared, means the contribution of influence given by the independent variable (X) to the dependent variable (Y). This coefficient aims to predict and see how much influence variable X has on variable Y.

Meanwhile, the regression equation in this research is used to predict the value of the dependent variable from the independent variable. The results of this study found that there was a positive correlation between the three variables. As shown in Figure 5, environmental knowledge has a statistically moderately positive correlation with the frequency of sustainability practices ($r = 0.41$, $p<0.05$). Second, environmental knowledge has a weak correlation with sustainability awareness ($r = 0.12$, $p> 0.05$), or no correlation (Figure 6). Third, the frequency of sustainability practices has low correlation with sustainability awareness ($r = 0.36$, $p < 0.05$), as shown in Figure 7. The direction of correlation in this study shows a positive correlation coefficient, meaning that the relationship between the two variables is directly proportional, meaning that the increase in variable X coincides with the increase in variable Y. In this graph, the correlation between variables has different coefficients of determination, or R squared values. The coefficient of determination value is used to predict the contribution of variables X and Y. First, the correlation coefficient of determination between environmental knowledge and the frequency of sustainability practices is 0.1652, or 16.52%. This means that the environmental knowledge variable influences the frequency of sustainability practices by 16.52%. Meanwhile, the rest is influenced by other variables outside of these factors or other variables that are not researched. Second, the correlation coefficient of determination between environmental knowledge and sustainability awareness is 0.0146, or 1.46%. This means that the environmental knowledge variable influences the sustainability awareness variable by 1.46%. Meanwhile, the rest is influenced by other variables outside of these factors or other variables. Third, the correlation coefficient of determination between the frequency of sustainability practices and sustainability awareness is 0.1296 or 12.96%. This means that the frequency of sustainability practices influences the sustainability awareness variable by 12.96%. Meanwhile, the rest is influenced by other variables outside of these factors or other variables. The smaller the value of the coefficient of determination, the weaker the influence of variable X on Y. On the other hand, if the R square value is closer to 1, the influence is stronger. However, because the R square value in this study is less than 0.5, the coefficient of determination category is in the moderate category.
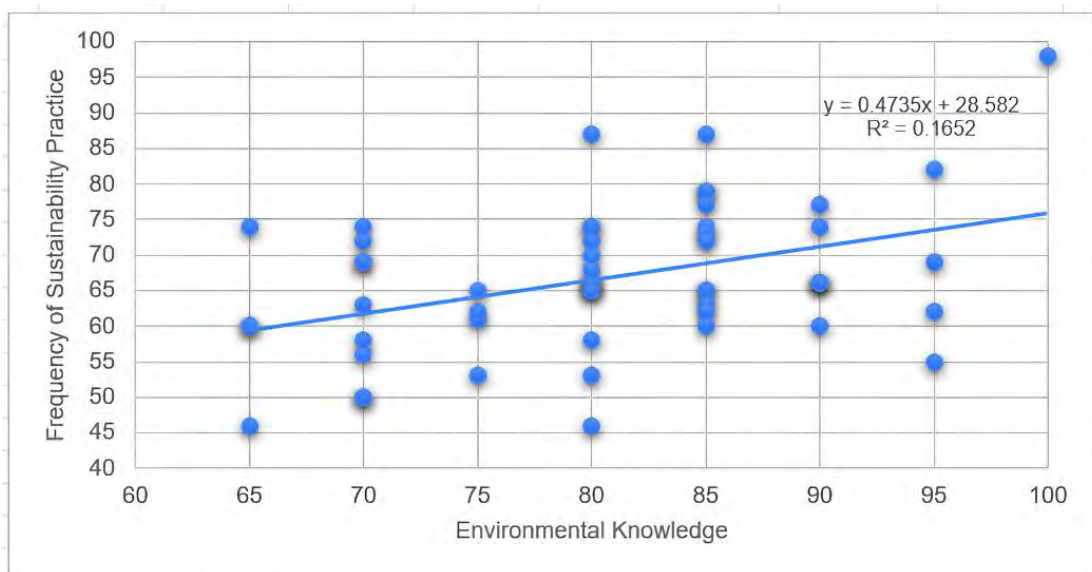

Figure 5. The correlation between students' environmental knowledge and sustainability practice
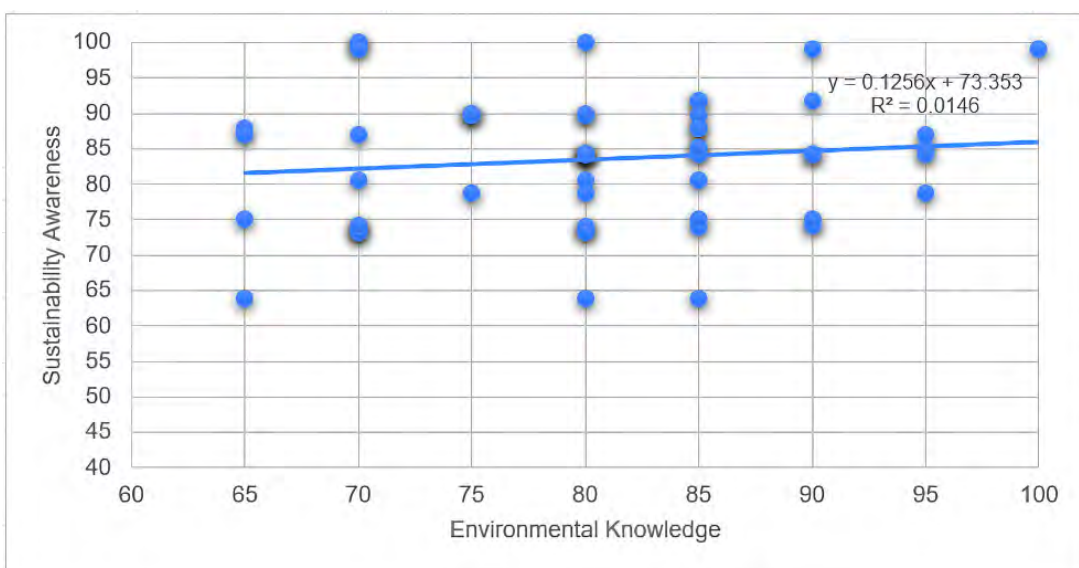
Figure 6. The correlation between students' environmental knowledge and sustainability awareness
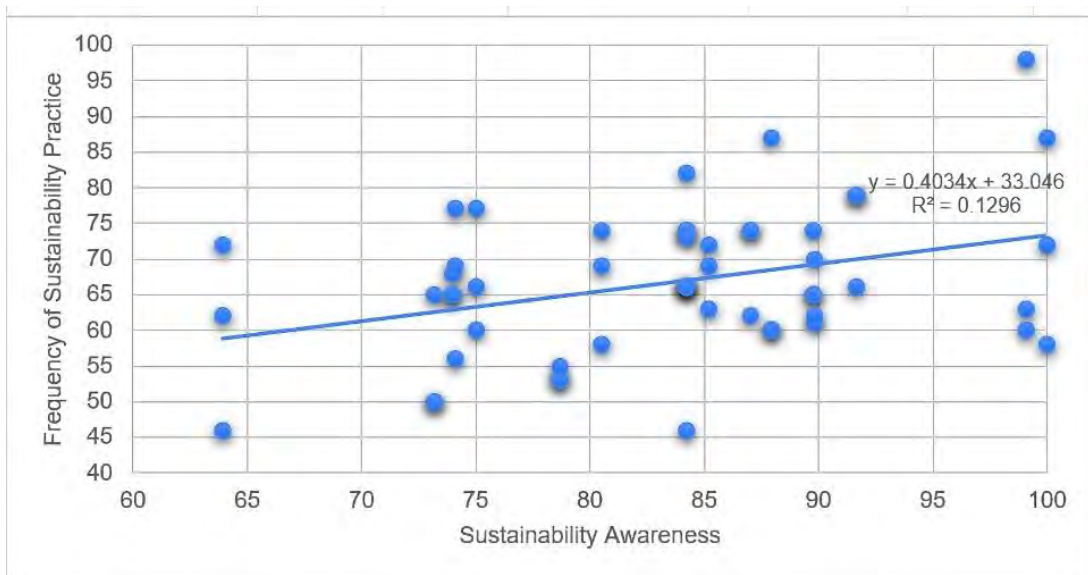

Figure 7. The Correlation between students' sustainability practice and sustainability awareness

Environmental knowledge has a statistically moderate correlation with the frequency of sustainability practices and a very weak correlation with sustainability awareness. The interpretation of the research results generally means that if the environmental knowledge score is low, it does not necessarily mean that students' sustainability awareness is also low, and vice versa. In other words, students who have knowledge are not necessarily aware of sustainability. Meanwhile, environmental knowledge is positively correlated with sustainability practices, meaning that when students' knowledge and level of awareness of sustainability are high, they will also tend to practice it frequently in everyday life. When students understand the concepts of global warming, climate change, water pollution, waste management, and ecology well, their daily practices are more sustainable than those of students with a low understanding of the concepts. Therefore, students' environmental knowledge can predict students' daily practices but cannot predict students' sustainability awareness.

The result of this study is supported by previous research. Research in the USA supported a statistically significant correlation between knowledge and attitude. In other countries, for example, Germany, programs that integrate agricultural activities are also carried out where children can participate in agricultural life, such as urban gardening projects such as community gardens in abandoned urban areas, botanical gardens, zoos, forest schools, conservation centers, and other centers. for environmental education (Otto & Pensini, 2017). The integration of nature-based environmental education enables the acquisition of environmental knowledge while fostering connectedness with nature

by providing students with natural contact and experience, so that their awareness of sustainability will also be built during the activity process.

Students with greater knowledge levels had a higher level of environmental attitudes and environmental behavior than students with lower knowledge scores (Zareie & Navimipour, 2016). However, other research in different countries found a weak association between knowledge and attitudes and between knowledge and behavior (Paço & Lavrador, 2017). The different findings can be caused by different ESD programs implemented for the students and different countries, so they may have a different curriculum of ESD and cultures since they are conducted in different countries. In addition, the study found that sustainability practice frequency has a statistically high correlation with Sustainability Awareness. When students know the importance of sustainability in the environmental, social, and economic aspects, they tend to do positive practices to take real action in reducing global warming, water pollution, and energy consumption. The previous similar research found that School Waste Education Program in school increased students' understanding and awareness of municipal waste, increased their pleasure in the program, and helped them improve their waste practices at home (Grodzinska-Jurczak et al., 2003). The present study found that students' sustainability awareness predicts their sustainability practice. Although the research connected sustainability consciousness and practice is limited in the literature, The Theory of Planned Behavior model can explain the causal relationship between them. According to this theory, there are three objects of environmental attitudes, as a set of valued objects, including individuals, other people, and the biosphere, which are interpreted in social-cognitive theory. They argue that individuals develop attitudes based on practice (Casaló & Escario, 2016). Several studies have found that students' environmental knowledge is correlated with their environmental attitudes and behaviors (Tang, 2018; Marcinkowski & Reid, 2019). Students with greater levels of knowledge have higher levels of environmental attitudes and behavior than students with lower knowledge scores (Zareie & Navimipour, 2016). However, other research in various countries found a weak relationship between knowledge and attitudes and between knowledge and behavior (Paço & Lavrador, 2017).

Knowledge, consciousness, and practice are a collection of human behaviors. The Knowledge, Attitude, Practice model asserts that a man with more knowledge influences the attitude or awareness, which influences their practice (Ramsey & Rickson, 1976). Therefore, students' knowledge sustainability of the environment can be connected to their awareness that will influence behavior. The students' awareness of sustainability occurs due to educational values and habituation to applying sustainability during the implementation of ESD in learning, which was carried out for several weeks. This creates awareness of sustainability because students are aware of the values of sustainability during several weeks of program implementation. This means that value education builds student awareness. However, increasing environmental knowledge does not mean increasing students' awareness as well. In the context of this research, the ESD program to improve students' knowledge of global warming, water pollution, waste management, and energy consumption can influence their awareness and practice of Sustainable Development Goals related to SDG6 (Clean Water and Sanitation), SDG7 (Affordable and Clean Energy), SDG13 (Climate Action), and SDG15 (Life on Land). The relationship between environmental knowledge and sustainability behavior is quite complex, and there are many factors that influence the relationship between students' understanding, beliefs, and actions.

This research has some implications for research, policy, and practice. For research, there are many complex factors in the social context that affect students' environmental care attitudes. Future research should explore the role of Environmental psychology, such as beliefs, norms, and values to predict environmental awareness such as family, school characteristics, the peers influencing students' pro-environmental attitudes (Prati et al., 2017). Since this research focuses on some SDG points, future research should also investigate other topics of ESD, such as students' sustainable consumption practices. For policy, the Indonesian government, via the Ministry of Education, should redesign ESD implementation in Senior High Schools. For example, the ESD should not only focus on theory but also emphasize the real action by transformative learning. The teaching method that reinforces misconceptions about global warming and climate change should be considered by biology teachers (Karpudewan et al., 2015). The teacher should also emphasize some specific environmental biology topics that males or females have a low understanding.

Conclusion

The application of ESD-PjBL in biology learning can increase the environmental knowledge of syudents. Students' score of environmental knowledge during the pretest and posttest shows a significant increase with moderate N-gain category. The average score of students' sustainability awareness also increased after ESD-PjBL, although it was not significant with low N-gain category. Although Indonesian high school students generally have high overall knowledge of the environment after ESD implementation in Biology lesson, they have low knowledge of global warming. After ESD implementation, students also have a high level of sustainability awareness and a high average frequency of practicing sustainability. However, the frequency of action to reduce global warming is relatively low. Secondly, when the result

is further analyzed based on gender, female students have statistically significantly higher environmental knowledge than male students ($p<0.05$) related to waste management. The female also has a higher understanding of almost all chosen topics of environment. Also, female students have higher Sustainability Consciousness in all specific domains of sustainability, including environment, social, and economic factors, and they have a statistically significant higher level of sustainability behavior than males ($p<0.05$). Thirdly, this study found that there was a positive correlation between the three variables. Environmental knowledge has a statistically moderately positive correlation with the frequency of sustainability practices ($r = 0.41$, $p<0.05$). Environmental knowledge has a weak correlation with sustainability awareness ($r = 0.12$, $p> 0.05$), or no correlation. The frequency of sustainability practices has low correlation with sustainability awareness ($r = 0.36$, $p < 0.05$). The direction of correlation in this study shows a positive correlation coefficient, meaning that the relationship between the two variables is directly proportional.

There are some limitations of this study. The researcher measured students' sustainability practice frequency and awareness via self-reporting, meaning that students can under or overestimate the scale according to their honesty during the survey. Therefore, future research can use other methods to measure students' awareness and practice, such as observation. Secondly, most participants are female because females dominate most senior high school students in Indonesia. Also, the research is conducted in only one private school in Jakarta. Therefore, further research should be conducted in Indonesia's public schools and rural areas. Then, the quantitative research design used in this study is a one-group pretest posttest design. The weaknesses of the research design are that there are no control group students.

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Conflicts of Interest

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

Author Contributions

H. Setiawan: proposal, writing original draft preparation, data collection, result, discussion, **H. K. Surtikanti:** methodology, review, proofreading, analysis; **K. Kusnadi and R. Riandi:** discussion, conclusion, and editing.

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