



Is STEM Learning can Significantly Effect Students' Sustainability Awareness?

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ABSTRACT

Sustainable awareness is one thing that individuals should possess as a form of concern for the environment. This research aims to analyze how the STEM learning model influences students' sustainable awareness. The study was conducted at one of the Madrasah Aliyah (MA) in Bengkulu City for 10th grade students. This research used a quasi-experimental method with a non-equivalent control group pretest-posttest design. The sample for this study consisted of 10th grade students, with two control classes and two experimental classes selected using convenience sampling techniques. The quantitative data in this study includes pretest and posttest scores processed using SPSS. There is also secondary data in this study that comes from unstructured interviews with teachers and students. There are three indicators of sustainable awareness in this study which are derived from the synthesis of several articles, namely knowledge awareness, attitude awareness, and participation awareness. The research results indicate a non-significant influence of the STEM learning model on students' sustainable awareness. Statistical tests were also conducted for the three indicators, with one indicator showing significant results and two indicators not showing significant results.

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Introduction

The issues of solid waste management has bcome a significant problem that needs to be urgently addressed by government in many countries worlwide. Solid waste management requires extensive service and has significant enviromental impacts. The costs incurred by the government are

substantial to resolve this issue. Currently, citites around the world generates less than 1.3 billion tons of solid waste per year, and this volume ins expected to continue increasing to 2.2 billion tons by the year of 2050 (Hoorweg, 2012). Uncontrolled accumulation of solid waste signficantly contributes to floods, air pollution and

various respiratory diseases, diarrhea and even dengue fever (DBD). The challenges of solid waste management will continue to increase globally with the growth of consumerism, economic development, and lifestyle changes. Some underlying obstacles leading to disruption in solid waste management include a lack of awareness, technology, funding and inadequate urban planning (Abubakar et al., 2022; Hettiarachchi et al., 2018; Scarlat et al., 2015). The issue of solid waste management is not only faced by large countries globally, but also poses a problem and challenge in Indonesia.

Almost every economic sector generates solid waste. Several factors influencing the amount of waste include population, economy, growth, education, employment, consumption pattern and the per capita income of region (Lestari & Trihadiningrum, 2019). Indonesia is reported to be the second-largest contributor to plastic pollution in the marine environment, following China (Jambeck et al., 2015; Tibbetts, 2015). Solid waste can be found everywhere, including in tourist areas, one of them is the beach. Solid waste is a serious issue that indirectly affects coastal and marine ecosystems worldwide ((Derraik, 2002; Ivar do Sul & Costa, 2007). Solid waste generated from various human activities including coastal tourist area. Many solid waste float along the the shoreline and in the shallow and deep parts of the sea. These wastes can be carried by ocean currents, becoming a serious global issue (Bergmann et al., 2017; Smith, 2012). One of the reason for the widespread presence of solid waste is the low environmental awareness among communities (Abubakar, 2017).

Awareness is defined as the conscious and sensitive attitude of an individual or social group towards its surrounding environment (Michael et al., 2020). On the other hand, environmental awareness is the consciousness and active involvement of the community in the environmental issue (Altin et al., 2014). Many factors influence human environmental awareness, such as education, academic level, gender, age, nationality, and community demographics (Al-Naqbi & Alshannag, 2018; Debrah et al., 2021; Illahaqi et al., 2021; Michael et al., 2020; Mojilis, 2019). Enhancing sustainable attitudes and behaviors, and it is an essential part of sustainable education (Shelest et al., 2017; Too & Bajracharya, 2015)

The improvement of knowledge, awareness and behavior of the community towards environmental issues is one of the focuses of activities in the context of sustainable development goals (SDGs)(UNESCO, 2017). One of UNESCO's programs to achieve the SDGs in education is through Education for Sustainable Development (ESD)(Ferronato et al., 2020; Sass et al., 2021). ESD stands for Education for Sustainable Development, where it is also defined as an educational effort expected to promote changes in knowledge, skills, values and attitudes for the community to adopt more sustainable behaviors (Clarisa et al., 2020; Eliyawati et al., 2022; Mogensen & Schnack, 2010). One learning model that can be integrated with ESD is the STEM learning model.

There have been many studies on the STEM learning in Indonesia. Some STEM research results shows positive outcomes for learning, such as STEM learning can yielding positive results in teachers' and students' perceptions of education(Saptarani

et al., 2019). STEM learning can also enhance students' problem-solving skills in the learning process. Additionally, STEM learning can improve students' learning outcomes because it allows student to be more actively engaged in the classroom (Wijayanto et al., 2020). There are also studies related to implementation of ESD in schools to achieve the goals of SDGs. Some research indicates that the integration of ESD in schools can enhance students' cognitive abilities and sustainability awareness (Clarisa et al., 2020). Moreover, the integration of TPACK with ESD can improve the TPACK-ESD skills of prospective biology teachers (Purwaningsih & Budhi, 2016)

However, despite the abundance of research on STEM and ESD, there are not many studies that integrate both STEM and ESD, and explore their connection with students' sustainability awareness when implemented in schools. Therefore, the researcher aims to investigate the impact of STEM learning integrated with ESD to achieve one of the SDGs. Through this learning activity, researcher intends to examine the significance of the learning process on students' sustainability awareness.

Method

This resarch has used a quasi-experiment research method, with the desain being a pretest-postest non-equaivalent control group design, where both classes, which is experiment and control class were used as the research subject. The experimental class will be taught using a project-based STEM learning model with the theme of solid waste management issues. Meanwhile, the control class will be taught with the usual teaching

models and methods used by teachers in the classroom.

This research was held at one of Madrasah Aliyah (MA) Kota Bengkulu in the odd semester of the academic year 2023/2024. The population of this research was students of class X MA Kota Bengkulu. MA has ten class of X classes. Sample were taken from the population using the convinience sampling tecnique. The sample in this study is class X 4 and X 10 as the control class, taught using the usual teaching models and methods by teachers in the classroom, and class X 5 and X6 as the experiment class taught using project-based STEM learning model with the theme of soid waste managment issue. There are 34 students in classes X4, X5, and X6, and 39 students in classes X10. Each class was given the same pre-test and post-test. The design of this study showed in Table 1

Table 1. Research desain

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The data on students' sustainability awareness of enviromental change material were obtained through pre-test and post-test in the form of a questionnaire given to students at the beginning and the end of the learning process, both in control and experimental class. This data is processed to observe its significance through the application of SPSS. There are 3 indicators with total of 30 statement items in the questionnaire. The indicator used in this questionnaire are knowledge of awareness, attitude of awareness, and particiaption of awareness. The qestionnaire instrument has been validated by experts and tested for readability among students before being utilized. These three indicator are developed based on the research analyses of Bouman et al., 2018; Gericke et al., 2019; Michalos et

al., 2012; Olsson et al., 2016; Pauw et al., 2015; Sen et al., 2021. The quantitative data is analyzed using an independent sample t-test with SPSS version 26 for Windows. In addition to the quantitative pretest and posttest data, there is also additional data in the form of unstructured interviews conducted with teachers and students. Interviews with teachers were conducted to understand their knowledge of the STEM learning model. Interviews with students were conducted to understand their understanding and knowledge of solid waste management issues and basic knowledge of the SDGs.

Results and Discussion

Based on the results of descriptive statistical tests, differences were found in the initial data between the experimental and control classes. The pre-test results showed that the average score of the experimental class was higher than that of the control class. However, after conducting a test of the

difference in means on the pre-test results of the experimental and control classes, it was found that this difference was not statistically significant (p -value 0.059). This indicates that initially, the sustainability awareness in both classes was at an equivalent level.

After implementing a treatment involving a project to address solid waste issues in the experimental class, differences in the average scores between the control and experimental classes were observed. The experimental class had a higher average score than the control class, both in the pre-test and post-test. However, based on the results of inferential statistical tests using a t-test for the difference in means, the experimental and control classes did not show a significant difference at the end of the learning period (p -value $0.144 > 0.05$). This suggests that, in general, the STEM-based learning process in this study did not have a statistically significant effect on the sustainability awareness of the students

Table 2. The results of the descriptive statistical test and the hypothesis test of sustainability awareness.

		Pretest		Posttest	
		Experiment	Control	Experiment	Control
N		74	73	74	73
Highest score		3	3	4	4
Mean (Max:4)		2.90	2.82	3.25	3.18
Lowest score		2	2	4	4
Standart Deviation		0.19	0.27	0.34	0.31
Normality Test (Kolmogorov Smirnov, Sig= 0.05)	Sig.	0.20	0.92	0.005	0.016
Homogeneity Test(Levene's Test, Sig= 0.05)	Sig	0.002		0.683	
Man Whitney Test	Sig	0.059		0.144	

The non-significant results in this study are certainly attributed to several factors, one of which is the limited implementation time

of the learning sessions, which was only four meetings. One of the challenges in implementing STEM in schools is the

constraint of limited time available to teach specific materials (Winangun & Kurniawan, 2019). Meanwhile, awareness and concern for the environment indeed require a long and gradual process to achieve the expected results (Noverita et al., 2022; Sitindaon et al., 2022; Yuningsih, 2019). This is because awareness is something that takes a long time to be ingrained and become a habit in an individual. Factors contributing to the non-significance of the results in this study will also be discussed in more detail for each indicator of sustainability awareness

Statistical testing was not only conducted on the overall awareness variable, but statistical tests were also performed on the three indicators of this awareness. The purpose of testing these three awareness indicators is to determine if there is any particular indicator that stands out and is influenced by STEM-based learning. The results of the statistical tests for the three awareness indicators can be seen in Table 3.

Table 3. The results of hypothesis testing for each indicator of sustainability awareness.

Indicators	Sig	Interpretation
Knowledge of Awareness		
<i>Pretest</i>	0.372	Not significant
<i>Posttest</i>	0.206	
Attitude of Awareness		
<i>Pretest</i>	0.007	Significant
Participation of Awareness		
<i>Pretest</i>	0.290	Not Significant
<i>Posttest</i>	0.651	

Knowledge of Awareness

The awareness of knowledge in this study pertains to students' awareness regarding their knowledge and understanding of solid waste management. This includes understanding what solid waste is, the various types of solid waste, the causes of poor solid waste management, and the impacts of inadequate solid waste management on society, social aspects, and the economy. The graph depicting the level of students' knowledge awareness before and after the treatment can be seen in Figure 1. From figure 1, it can be seen that there is no significant difference apparent from the results of the pre-test and post-test both the

control and experiment classes regarding students; knowledge of awareness.

Based on inferential statistical testing using a t-test for the difference in means, the results indicate that both the pre-test and post-test, STEM-based learning in this study did not have a significant effect on students' knowledge awareness (*p-value* 0.206 > 0.05).

Unfortunately, despite numerous studies stating that the implementation of STEM learning significantly influences students' conceptual knowledge, such a significant impact was not observed in this study. Several factors could contribute to this outcome. One factor that might explain the lack of significant influence of STEM-

based learning on students' conceptual knowledge awareness is the teachers' ability to implement the STEM learning model. This aligns with previous research suggesting that some factors hindering the implementation of STEM learning in classrooms include the teachers' insufficient competence in the STEM learning model and a lack of collaboration with professionals or experts related to STEM. (Susilo & Sudrajat, 2020). A teacher's ability to deliver instruction significantly influences the learning outcomes, including the knowledge of the students (Thahir et al., 2020).

The discussion regarding why STEM learning does not influence students' sustainability awareness is also supported by result of unstructured interviews with the teacher. After the learning session, the researcher conducted interviews with teachers about the STEM learning model. One of the questions asked were “*have you heard of the STEM learning model before? If yes, have you ever used the STEM learning model in your classroom?*”. The response from the teacher involved was they had not heard of or used the STEM learning model before.

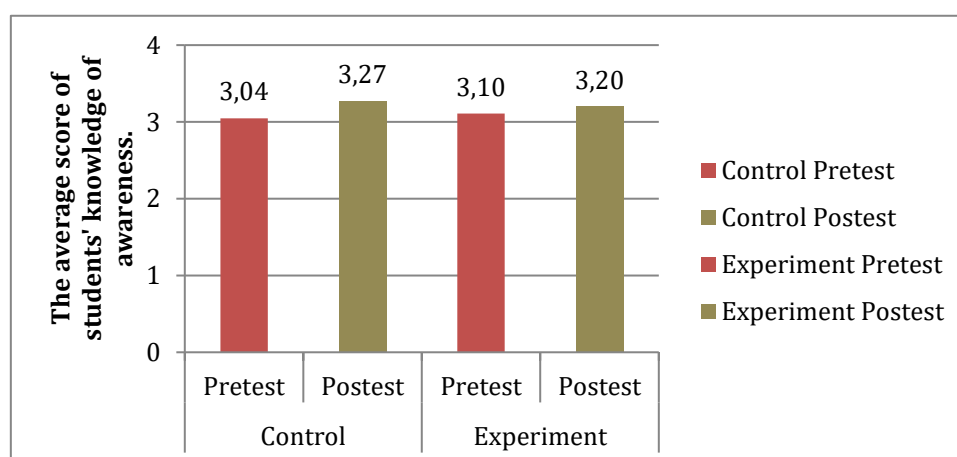


Figure 1. Awareness of Knowledge

Attitude of Awareness

The awareness of attitude in this study aims to examine how students become aware of and improve their attitudes toward the issues related to solid waste management that they encounter in the field. The graph in Figure 2 shows the difference in the average values of students' attitude awareness before and after the treatment. Based on inferential statistical testing using a t-test for the difference in means, there is a significant difference in students' attitude awareness (p -

value $0.008 < 0.05$). This indicates that the STEM-based learning model can have a significant influence on students' attitude awareness. The results of this study are consistent with research stating that STEM learning can influence students' environmental awareness and concern (Rahmanda, 2023; Listari, 2023), because STEM learning individually can build a relationship between knowledge, attitudes, and environmentally conscious behavior among students. The environmental

attitudes of students significantly influence their awareness, both within and outside of school (Dasrita et al., 2015). Through STEM education, it is expected that students will have the opportunity to enhance their environmental awareness and concern. Attitude awareness in an individual is

considered a significant driver, especially among students. Attitudes can control how a student will behave and respond to issues related to waste management, influencing their behavior and how they act beneficially towards the environment. (Owojori et al., 2022)

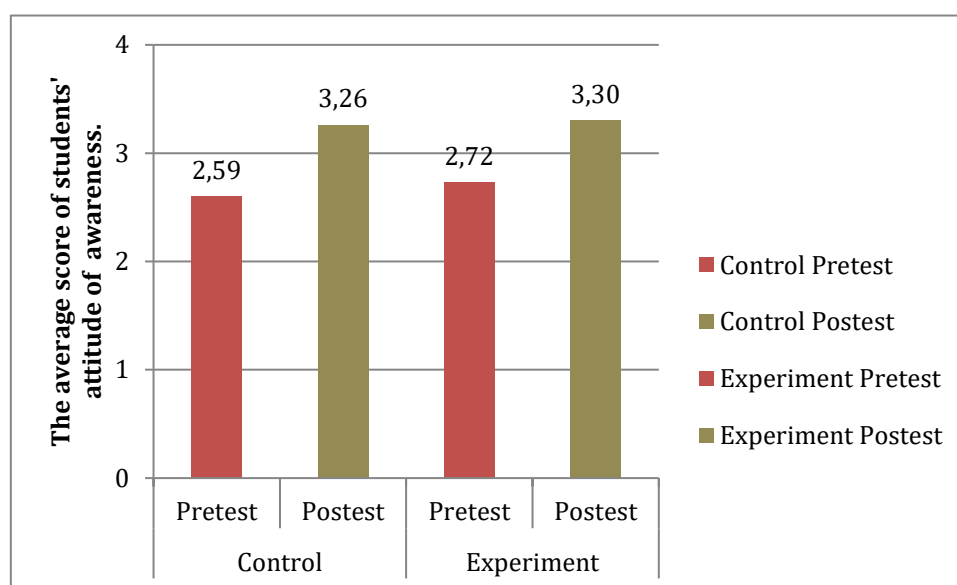


Figure 2. Awareness of Attitude

Awareness to participate

Awareness to participate in this study aims to observe how students are aware of taking action, reacting and participate to the issues of solid waste management they encounter in the field. The graph depicting the level of awareness to participate in students can be seen in Figure 3. Based on inferential statistical testing using a t-test for the difference in means, similar to knowledge awareness, there is no significant difference in awareness to take action (p -value $0.651 > 0.05$). This indicates that the STEM-based learning model in this study did not have a significant impact on students' awareness to participate.

This is consistent with research indicating that emotionally, students can have positive attitudes and high concern for the environment. However, students rarely

or even never take any action or respond to address something. This may be due to the lack of habituation among students regarding sustainability practices, leading them to rarely or even never take action regarding these issues (Ekamilasari Ekamilasari et al., 2021)

This is also in line with the results of brief interviews conducted with students in the experimental class. Most students imagined that they had to do something significant when they heard the word "Involved." Therefore, the students thought that it was impossible for them to do such things. They believed that making small changes would not have any impact. The issue of solid waste management is a significant problem, so students perceived that addressing and taking responsibility for such major issues is the government's role.

(Parker, 2018). Another factor that could contribute to the low awareness of students regarding the awareness to participate is that

students tend to lack confidence in themselves.

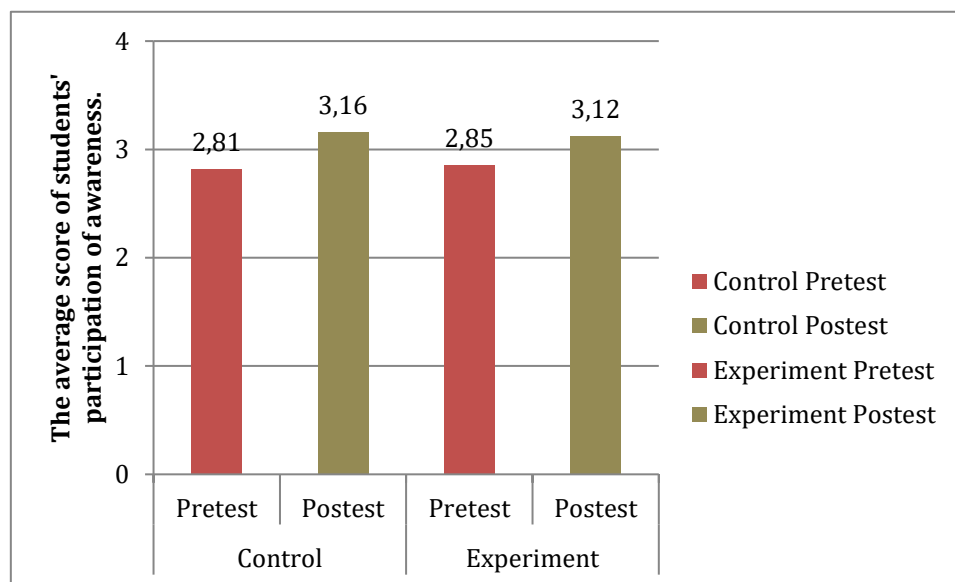


Figure 3. Awareness to participate

Conclusion

Overall, STEM-based solid waste management education in this study did not yield significant results in students' sustainable awareness. As mentioned earlier, statistical tests were conducted for each indicator. The results of the statistical tests for the indicators of sustainable awareness variables showed that there were no significant findings for the indicators of knowledge awareness and participation awareness among students. However, significant results were observed only for the attitude awareness indicator among students.

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