



PROJECT-BASED LEARNING CONTAINS SUSTAINABLE DEVELOPMENT GOALS: THE EFFORTS TO IMPROVE STUDENTS' SUSTAINABILITY AWARENESS

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Abstract

Students have a sustainability awareness level from a lack of knowledge, attitude, and behaviour. The purpose of this study is to implement SDGs-contained PjBL on Biotechnology material as one of the efforts to improve the students' sustainability awareness. The research method is a quasi-experiment by nonequivalent control group design. The research sample is 32 students of the control class and 34 students of the experiment class of class-XII Senior High School. The data-collecting technique is using questionnaires and learning observations. The sustainability awareness questionnaire has 18 question items and consists of three indicators i.e., sustainability knowingness, sustainability attitudes, and sustainability behaviour adapted from the Sustainability Consciousness Questionnaire Short (SCQ-S). The data analysis uses an Independent Sample T-test and N-Gain Test. The result of the Independent Sample T-Test shows not that much significant difference between the experiment and control classes' pretest average ($0.509 > 0.025$). The experiment and control classes' posttest average results show not that much significant difference ($0.000 < 0.025$). The N-Gain score result of the experiment class shows students' sustainability awareness improvement after conducting SDGs-contained PjBL in the medium category (N-Gain = 0.4869). The improvement follows the result of SDGs-contained PjBL implementation on 93.03% of teachers, and 90.96% of students in the excellent category. These research findings are obtained through SDGs-contained PjBL, students' sustainability knowingness, and sustainability attitudes, especially on the social dimension which experiences higher improvement.

Keywords: Sustainability Awareness; Sustainability Knowingness; Sustainability Attitudes; Sustainability Behaviour; Project-Based Learning; Sustainable Development Goals.

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INTRODUCTION

Sustainability Awareness is an awareness of sustainable phenomena covering environment, social, and economic perspective. The sustainability awareness refers to experience and perception related to faith and action in the sustainable development context (Marcos-Merino et al., 2020). Three indicators of sustainability awareness i.e., sustainability knowingness, attitudes, and behaviour (Gericke et al., 2018).

The research of Olsson et al. (2016) shows the students' sustainability awareness decreased in Sweden which indicates a sustainability education for teenagers requires modification. Education Sustainable Development-certified (ESD) schools do not offer a consistent learning approach by ESD. This research also states that ESD in school shall be adapted differently for every level of education.

Environmental damage issues in the future are caused by the lack of knowledge of the importance of maintaining environmental sustainability supported by sustainability awareness (Kurniasari et al., 2020). Further findings reveal that students' sustainability awareness is from low knowledge, attitude, and behaviour aspects. Social and ecology behaviors are not oriented toward sustainability (Ridwan et al., 2020). Students often only learn cognitive matters in class and do not focus on sustainability awareness (Kurnia et al., 2020). The research of Michael et al. (2020) shows the conclusion that students have low sustainability knowingness. Other research states that students' awareness and knowledge of the environment are still low (Wulandari et al., 2017).

The United Nations (UN) established Sustainable Development Goals (SDGs) to solve the lack of sustainability education issues (United Nations, 2015). Education plays an active role in leading students to improve environmental awareness and knowledge as well as a responsible attitude (Miranto, 2017). Education can take a role in improving sustainability awareness by including sustainability principles in the education curriculum (Michael et al., 2020). Learning in the Independent Curriculum that has a purpose in realizing SDGs is conducted by implementing knowledge in daily life

related to environmental issues. Learning are not limited to academic theories but it is conducted by integrating the practice in life, especially dealing with environmental issues (Kemendikbudristek, 2022). However, the Independent Curriculum is still hard to implement teachers in working projects so it requires various implementations in the learning model (Nurazizah et al., 2023).

The research of Masdiana et al. (2020) shows that do not explain the aspect which trains students' sustainability awareness on project-based learning is not done. Therefore, the project-based learning result that is done significantly improves students' awareness toward the school environment. Therefore, a sustainability aspect like Sustainable Development Goals (SDGs) in PjBL is required to be able to improve students' sustainability awareness.

The process that involves SDGs in the Project-Based Learning (PjBL) can become a contributing solution for students' sustainability awareness improvement. Through PjBL, students can become active and innovative (Rahayu et al., 2019) as well as involved in real relevant projects by sustainability and implement sustainability principles in practice (Jääskä et al., 2021). SDGs-contained PjBL is required for expansion of the students' sustainability awareness that can play a role in moral decisions in the future (Marcos-Merino et al., 2020).

This research uses biotechnology material. The survey result shows that students consider biotechnology material as one of the most difficult materials (Duda et al., 2020). Students still have difficulty understanding the concept of fermentation (Zega, 2022). The occurrence of misconception causes low students' understanding of biotechnology concepts (Irani et al., 2020). Low understanding can cause students to fail in making fermentation products. Students experience difficulties in improving scientific ideas and have low knowledge related to making fermentation products (Chan et al., 2021). Nature resource utilization in the making of fermentation products has not yet reached maximum (Saputra et al., 2022). The importance of utilizing natural resources wisely is required to be able to sustainably utilize

(Kusumawati et al., 2023). Gramatik (2020) mentioned that utilizing local potential in biotechnology practice is not adequate yet. The fermentation concept can be understood through practice by making fermentation-processed products through SDGs-contained PjBL.

SDGs cover 17 wider and more comprehensive purposes from various sustainable development aspects (United Nations, 2015). Sustainable Development Goal 12 (SDG 12) on Responsible Consumption and Production is the most supported biotechnology material in improving sustainability awareness. The purpose of these SDGs focuses on the effort to encourage awareness of sustainable consumption and production patterns. The efforts that can be done according to SDG 12 are reducing waste, maintaining resources efficiently by reducing, preventing, reusing environmentally friendly things, recycling, and improving product quality efficiency, as well as optimizing energy and design (United Nations, 2015). Biotechnology material in this research refers to the food sector by implementing fermentation concepts. Biotechnology is a branch of science that requires understanding of basic concepts as foundation to learn (Purwianingsih et al., 2010). Biotechnology material fermentation concepts played a role in food production to reduce global poverty value.

The purpose of this research referred to the description above is to implement SDGs-contained PjBL in the Biotechnology material as one of the efforts to improve students' sustainability awareness. By improving sustainability awareness in biotechnology learning through the SDG 12-contained project which is Responsible Consumption and Production, students are expected to have a deeper understanding on biotechnology implications towards the environment, social, and economy as well as the importance of considering sustainability in development and its implementation. This knowledge will allow individuals to make decisions and take action that support sustainable biotechnology practice. PjBL also emphasizes student center-learning so that students can solve an issue based on the learned concept (Mursid et al., 2022).

METHOD

The research method uses quasi-experiments by nonequivalent control group design. This design uses control and experiment classes that are not picked randomly. The purpose of the selection is not randomly picked to recognize a particular given treatment (Creswell, 2014). The participants of this research are students of class-XII Senior High School from one of Senior High Schools in West Bandung Sub-District. Samples consist of 66 students chosen by purposive sampling. About 34 students in the experiment class who received SDGs-contained PjBL treatment and 32 students in the control class who received PjBL treatment. Both classes conduct a pretest and posttest using a sustainability awareness questionnaire. The questionnaire statements are used to recognize sustainable knowledge, sustainable attitude, as well as sustainable behaviour of the students. Questionnaire can be used as the initial test (pretest) or final test (posttest) (Wenemark et al., 2022). Other study shows that pretest can be done in various forms, including questionnaire, and can be used as posttest to assess various learning results (Lenzner et al., 2023).

The research uses instruments that cover sustainability awareness questionnaires and observation sheets of SDGs-contained PjBL implementation. The 18 statement items of the sustainability awareness questionnaire is the adaptation result from Sustainability Consciousness Questionnaire-Short (SCQ-S) by Gericke et al. (2018). The questionnaire consists of 3 indicators of sustainability awareness i.e., sustainability knowledge, attitude, and behaviour covering the three dimensions namely environmental, social, and economic dimensions. Following Marcos-Merino et al. (2020), the three indicators and dimensions become sustainability environmental knowledge, sustainability economic knowledge, sustainability environmental attitudes, sustainability social behaviour, and sustainability economic behaviour. Statement questionnaires are answered on Likert range scale from 1 (very disagree) to 5 (very agree).

Sustainability awareness questionnaire reliability has been tested before the research took place using validity and reliability tests. Validity

and reliability testing is done through trials for 26 students of class XII. The validity test result shows that all statements in the questionnaire are proven to be valid ($p > 0.025$). The reliability test shows that all tested questions obtain Cronbach's Alpha in the amount of 0.884 which shows a very high reliability.

The pretest and posttest result data of students' sustainability awareness questionnaires are managed and analyzed using Statistical Package for the Social Science 26.0 (SPSS version 26.0). The data analysis covers precondition tests, median tests, and N-Gain tests. The results of students' sustainability awareness are categorized into three categories, i.e., 1 to 2.33 score average are belong to lower category, 2.34 to 3.66 are belong to medium category, and 3.67 to 5.00 are belong to high category (Hassan et al., 2010).

Observation sheets are used to obtain SDGs-contained PjBl implementation data on teachers and students. The observation sheets consist of activities done at every learning stage following the learning module adapted from Syarif (2017). PjBL model stages that are used as follows: 1) Start with the essential question; 2) Design a project plan; 3) Create a schedule; 4) Monitor the students and the progress of the project; 5) Assess the outcome; and 6) Evaluate the experience. The activities of teachers and students during learning are using SDGs-contained PjBL for 5 meetings observed by three observers i.e., two researchers and one teacher. The result of monitoring activity of teachers and students scored based on Likert scale in range from 1 (very disagree) to 5 (very agree). The percentage obtained score is counted by adding up all obtained scores then divided by the maximum score, and then the divided result is multiplied by a hundred. The percentage calculation was interpreted following the implementation result category namely 0 to 20 (very insufficient), 21 to 40 (insufficient), 41 to 60 (medium), 61 to 80 (good), and 81 to 100 (Excellent) (Ekantini et al., 2018).

The normality test is conducted to recognize the pretest and post-test data distribution using the Shapiro-Wilk test because of the number of samples < 100 . Meanwhile, the homogeneity test is conducted to recognize the variety of homogeneity

of the pretest and post-test data. Homogeneity tests use Levene's Test because the test is conducted on two data groups. Median tests use Independent Sample T-Test tests because the precondition test result shows data is distributed normally and homogeneously.

Normalized gain calculation (N-Gain) is conducted to recognize students' sustainability awareness improvement after treatment. N-Gain calculation is conducted when there is significant difference in median post-test between experiment class and control class. N-Gain interpretation based on the Hake category (1999) consists of three categories; $N\text{-Gain} > 0.7$ (high), $0.3 \leq N\text{-Gain} \leq 0.7$ (medium), $N\text{-Gain} < 0.3$ (low) (Hake, 1999).

RESULTS AND DISCUSSIONS

Students' Sustainability Awareness Achievements Through SDGs-contained PjBL

The pretest and post-test result data of students' sustainability awareness questionnaires are distributed normally and homogenous (Table 1). This allows the conducting of parametric tests i.e., median test using an Independent Sample T-Test (T-test) with an alpha score of 2.5%. This T-Test is purposely to assess if there is significant difference or not between control and experiment class before and after treatment.

Analysis from the T-Test on pretest data shows that there is no significant difference between the control and experiment classes before treatment ($p > 0.025$, namely in the amount of 0.509). This finding follows the research of Utama (2019) which shows significant indifference between the pretest of the control and experiment classes related to the PjBL implementation. In addition, the pretest result has the purpose of recognizing students' initial sustainability awareness. So this finding can happen because the students' understanding of both classes are similar (Utama, 2019). Analysis from the T-Test on post-test data shows significant difference between the control and experiment classes after given treatment ($p < 0.025$, namely in the amount of 0.000). The post-test result shows that SDGs-contained PjBL learning in the experiment class produces a significant difference than PjBL-applied learning in the control class.

Table 1. Pretest and Post-test Statistics Test Result of Students' Sustainability Awareness

Data Types	Pretest		Post-test	
	Control	Experiment	Control	Experiment
N	32	34	32	34
Score Average	3.10	3.15	3.66	4.32
Score Average Category	Medium	Medium	Medium	High
Deviation Standard	5.64	5.16	5.40	5.40
Normality Test (Shapiro-Wilk)	Significancy	0.525	0.364	0.188
	Interpretation	Normal	Normal	Normal
Homogeneity (Levene's Test)	Significancy	0.942		0.088
	Interpretation	Homogen		Homogen
Median Test (<i>Independent Sample T-test</i>)	Significancy (<i>2-tailed</i>)	0.509		0.000
	Interpretation	Not different significantly		Significantly different

The improvement of students' sustainability awareness after treatment is known from the N-Gain calculation. The N-Gain average of the experiment and control classes have differences and different N-Gain index categories. Based on the overall N-Gain in the control class, it has an N-Gain average in the low category (N-Gain = 0.2114). N-Gain average in the control class in the high category is reached by 0 students (0%), the medium category is reached by 12 students (37.5%), and the low category is reached by 20 students (62.5%). Based on the overall N-Gain in the experiment class, it has an N-Gain in the medium category (N-Gain = 0.4869). N-Gain average of the experiment class in the high category is reached by 4 students (11.76%), the medium category is reached by 21 students (61.77%), and the low category is reached by 9 students (26.47%). Overall, by the N-Gain score, it is known that students' sustainability awareness improvement after conducting SDGs-contained PjBL is higher than the students' sustainability awareness after conducting PjBL.

This finding follows with previous research by Masdiana et al. (2020) which has a purpose of improving environmental awareness. In the learning process in the research of Masdiana et al. (2020), students are expected to be able to solve the school's environmental waste management. However, the result was PjBL has not been implemented significantly to improve students' awareness toward school environment. In addition, PjBL can cause changes in students' attitude on sustainability (Perrault et al., 2018). Attitude is a habit of acting and responding to stimuli received (Vaiqoh et al., 2021). Following this finding

research that the applied PjBL in the control class can improve student's sustainability awareness but the improvement is lower than the experiment class.

Students' Sustainability Awareness Achievement Through SDGs-contained PjBL in Each Indicator and Dimension

This research uses three indicators according to Gericke et al. (2018) i.e., sustainability knowingness, sustainability attitudes, and sustainability behaviour. Each indicator consists of three dimensions according to sustainability development pillars, namely social, environmental, and economic dimensions. Initial data of each indicator of the students' sustainability awareness before implementing learning obtained from pretest score average (Figure 1).

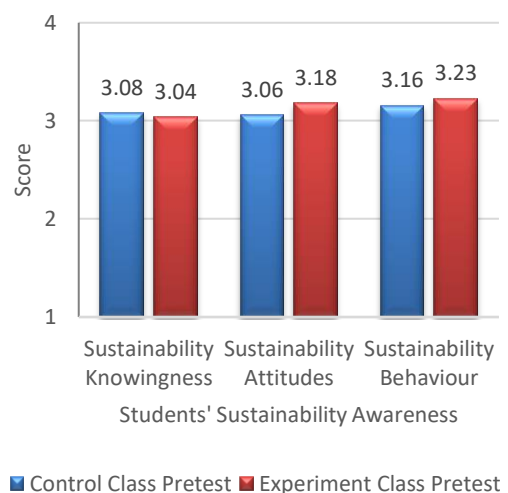


Figure 1. Sustainability Awareness Pretest Score Average Graphic in the Control and Experiment Class

In the control and experiment classes, the highest pretest score average is in the sustainability behaviour indicator. Sustainability behaviour indicator has the lowest pretest score in the control class. while the lowest indicator of the experiment class is the sustainability knowingness (Figure 1). The result of the overall pretest average in the control and experiment classes show that the students' sustainability awareness before treatment is in the medium level, with the overall pretest average in the control class is in the amount of 3.10 (SD= 5. 64) and in the experiment class is in the amount of 3.15 (SD= 5.16). The initial knowledge of students before given treatments are similar because seeing from the pretest score average in the control and experiment classes are included in the medium category. The previous research finding states that the students' sustainability awareness pretest average are included in the medium category (Setiawan et al., 2023). Protest scores in the control and experiment classes reflect the same population before given treatment (Morris, 2007).

Next, post-test data is collected after treatment using the Implementation of PjBL in the control class and SDGs contained PjBL in the experiment class. The Final data of students' sustainability awareness after treatment is obtained from the post-test score average (Figure 2). Based on the post-test score average result, sustainability behaviour indicator obtains the highest score in the control class and sustainability knowingness indicator obtains the highest score in the experiment class. Both highest scores belong to the high category, however, the highest score in the experiment class is higher. Sustainability behaviour score average in the control class is in the low category while in the experiment class. it is in the high category (Figure 2). Overall, the three indicators in the experiment class belong to the high category while in the control class, only sustainability attitudes indicators belong to the high category.

The overall average of post-test in the control class shows that students' sustainability awareness after going through PjBL is in the medium level (overall average of post-test is 3.66; SD= 5.40). Students' sustainability awareness score

in the experiment class after going through the SDGs-contained PjBL is in the high level (overall average of post-test is 4.32; SD= 5.40). Based on the previous research, it is proven that PjBL gave positive impacts towards students' sustainability awareness. However, PjBL did not give significant improvement in students sustainability awareness (Maulina et al., 2023). On the other hand, PjBL containing SDGs has provided an increase in sustainability awareness and improved students' social and emotional skills (Agusti et al., 2019; Yuan et al., 2021).

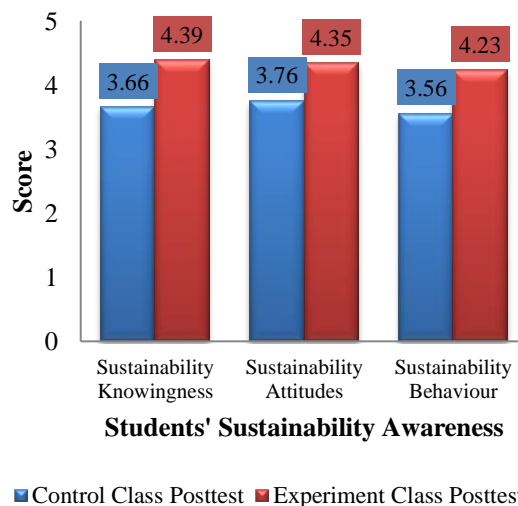


Figure 2. Sustainability Awareness Post-test Score Average Graphic in the Control and Experiment Classes

PjBL is a perfect model to explore sustainability issues and solves problem (Coronado et al., 2021). Therefore, SDGs-contained PjBL gives bigger influence than PjBL. Table 2. presents average scores and improvement to pretest-post-test in each indicator and dimension of sustainability awareness in the control class. Table 2 shows that the highest posttest average and increase in learning in the control class with the PjBL model was in the indicator of sustainability social attitudes (posttest average 3.91 and increase 1.30) while the lowest level of sustainability economic behaviour was low (average-posttest average 3.23 and an increase of 0.12). The dimension of sustainability awareness with the highest increase is the social dimension in the indicators of sustainability social attitudes, sustainability social knowledge and sustainability

social behaviour. The dimension of sustainability awareness with the lowest increase is the economic dimension in the indicators of sustainability economic attitudes, sustainability economic knowledge and sustainability economic behaviour.

These findings are in line with the theory that direct experience of being involved in project work can develop a more positive attitude towards sustainability so that it has an impact on increasing sustainability attitudes (Mahendra, 2017).

Table 2. The Average and Sustainability Awareness Pretest-Post-test Improvement Results of Students in the Control Class

Indicator	Pretest	Category	Posttest	Category	Improvement
Sustainability environmental knowingness	3.16	Medium	3.69	High	0.53
Sustainability social knowingness	2.81	Medium	3.84	High	1.03
Sustainability economic knowingness	3.28	Medium	3.45	Medium	0.17
Sustainability environmental attitudes	3.11	Medium	3.70	High	0.59
Sustainability social attitudes	2.67	Medium	3.97	High	1.30
Sustainability economic attitudes	3.39	Medium	3.61	Medium	0.22
Sustainability environmental behaviour	3.39	Medium	3.64	Medium	0.25
Sustainability social behaviour	2.98	Medium	3.80	High	0.82
Sustainability economic behaviour	3.11	Medium	3.23	Medium	0.12

Mahendra (2017) emphasized the importance of using appropriate and accurate learning models. The effectiveness of learning using PjBL can increase the potential for increasing sustainability awareness. Other research emphasizes that teachers play an important role in preparing Learning Implementation Plans (RPP) using the PjBL model for effective results (Turiyah, 2023). The effectiveness of PjBL in improving students' scientific attitudes can foster sustainability attitudes (Saepudin, 2020). These findings collectively suggest PjBL can influence

sustainability awareness, in line with the finding of a greater impact on sustainability attitudes and sustainability knowingness compared to sustainability behaviour. Other research also found that students' sustainability awareness had the highest score on sustainability attitudes, followed by sustainability knowingness, and sustainability behaviour (Marcos-Merino et al., 2020). Table 3 shows the average results and pretest-posttest increases in each indicator and dimension of sustainability awareness in the experimental class.

Table 3. Average Results and Pretest-Posttest Improvement of Students' Sustainability Awareness in the Experimental Class

Indicator	Pretest	Category	Posttest	Category	Improvement
Sustainability environmental knowingness	3.13	Medium	4.37	High	1.24
Sustainability social knowingness	2.81	Medium	4.54	High	1.73
Sustainability economic knowingness	3.19	Medium	4.25	High	1.06
Sustainability environmental attitudes	3.13	Medium	4.32	High	1.19
Sustainability social attitudes	3.10	Medium	4.51	High	1.41
Sustainability economic attitudes	3.31	Medium	4.22	High	0.91
Sustainability environmental behaviour	3.19	Medium	4.31	High	1.12
Sustainability social behaviour	3.13	Medium	4.38	High	1.25
Sustainability economic behaviour	3.35	Medium	4.00	High	0.65

Table 3 shows that the highest posttest average and increase in learning in the experimental class with the SDGs-laden PjBL model was in the sustainability social knowledge

indicator (posttest average 4.54 and increase 1.73) while the lowest level of sustainability economic behaviour was low (posttest average 4.00 and improvement 0.65). The dimension of

sustainability awareness that received the highest improvement score was the social dimension on the indicators of sustainability social knowledge, sustainability social attitudes and sustainability social behaviour. The dimension of sustainability awareness that received the lowest improvement score was the economic dimension on the indicators of sustainability economic knowledge, sustainability economic attitudes and sustainability economic behaviour.

PjBL containing SDGs increases students' understanding of sustainable issues (Setiawan et al., 2023). PjBL containing SDGs helps students understand the complexity of sustainable issues from various perspectives which can increase students' knowledge. By incorporating SDGs content into learning, students will be able to increase understanding of sustainable issues compared to students who learn using PjBL alone. Integrating SDGs into learning can also improve students' good attitudes (Rahayu et al., 2021). These findings are in accordance with research by Coronado et al. (2021) PjBL containing SDGs emphasizes students' acquisition of knowledge about sustainability so that sustainability knowingness gets a higher score than other indicators.

The social dimension in this study received the highest score in the control and experimental classes, followed by the environmental and economic dimensions. The social dimension has a strong emotional impact on students so it will be easier for students to agree with social statements (Olsson et al., 2015). The next highest score obtained was the environmental dimension. The environmental dimension is the dimension most known to high school teachers so that teachers focus on environmental problems and environmental traditions. This is followed by environmental dimensions and economic dimensions. Increasing sustainability awareness through PjBL is highest in the social dimension, followed by the environmental dimension and the economic dimension. Other research also found that students' sustainability awareness dimensions had the highest scores on the social, environmental and economic dimensions (Marcos-Merino et al., 2020).

Implementation of PjBL Containing SDGs for Teachers and Students

The activities of teachers and students during learning using PjBL containing SDGs were observed by three observers, namely two researchers and one teacher using an implementation observation sheet. Table 4 shows the results of implementing PjBL containing SDGs for teachers and students.

Table 4. Results of Implementation of PjBL Containing SDGs for Teachers and Students

SDGs-Contained PjBL Meetings	Teachers' Implementation Average (%)	Category	Students' Implementation Average (%)	Category
1st Meeting (Start with the essential question stage)	91.13	Excellent	88.22	Excellent
2nd Meeting (Design a plan for the Project and Create a Schedule stages)	92.06	Excellent	91.90	Excellent
3rd Meeting (Project assignment)	93.33	Excellent	90.00	Excellent
4th meeting (Monitor the students and the progress of the project stages)	95.11	Excellent	92.44	Excellent
5th meeting (Assess the outcome and evaluate the experience stages)	93.49	Excellent	92.22	Excellent
Average	93.03	Excellent	90.96	Excellent

Based on Table 4, overall the implementation of PjBL containing SDGs for teachers and students obtained an implementation percentage of 93.03% for teachers and 90.96% for students. From these results it can be interpreted that the PjBL containing SDGs is progressing very well. It can be concluded that PjBL containing SDGs is very good as a treatment in this research to increase students' sustainability awareness.

CONCLUSION

The conclusion of this research is that learning with the PjBL model containing SDGs in the experimental class can increase students' sustainability awareness. The increase in students' sustainability awareness in the experimental class was higher than in the control class. The increase in students' sustainability awareness after carrying out PjBL in the control class has an N-Gain score in the low category, while the increase in sustainability awareness after students carry out PjBL containing SDGs in the experimental class has an N-Gain score in the medium category. The results of the mean difference test T test after learning PjBL containing SDGs in the experimental class produced a significant difference compared to learning in the control class which implemented PjBL. In particular, students' sustainability awareness scores were higher on indicators of sustainability knowlengness and sustainability attitudes, especially in the social dimension.

This finding is in line with the implementation of PjBL containing SDGs in the experimental class. The average observation score on the implementation of PjBL containing SDGs for teachers and students as a whole is in the very good category. The suggestion from this research is to apply technology in working on fermentation projects during PjBL containing SDGs. The technology in question is information technology which involves the use of software and hardware as well as technology in the form of tools that lead to work efficiency. The use of technology aims to assist students in understanding, designing and developing innovative and sustainable fermentation projects.

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