Empowering Sustainability through Arduino-Enhanced Experimentation with Natural Fiber Filters for Air Purity in Contextual Teaching Approach to Support Sustainable Development Goals (SDGs)

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***Abstract*- This research was conducted to develop science learning for vocational students related to problems that are currently one of the focuses in sustainable education, namely air quality which has adverse effects on humans. Science learning with a contextual approach will be more easily understood by students, accompanied by experiments that can be done directly by students. This research uses the experimental method by starting with the manufacture of experimental equipment related to air pollution. Indonesia is rich in natural fiber, Thus, it can be used as a filter to reduce air pollution produced by motor vehicles, the majority of which are owned by vocational school students. The tools made for this experiment are very affordable and can simultaneously measure air quality before and after the use of filters with natural fiber in motorcycle exhaust. The measuring instrument used to measure air quality uses an Arduino Uno device and an MQ-135 sensor. This experiment set is one of the innovations in education. The learning that has been carried out has shown a significant increase in student learning outcomes, although there are still misconceptions among students. The results also show that students are motivated to follow this learning and become aware of sustainable development, especially related to air pollution.**

***Keywords*- Sustainability; Arduino; Experimentation; Natural Fiber Filters; Air Purity; Contextual Teaching**

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I. INTRODUCTION

Almost the entire world is experiencing problems with air quality. Indonesia is one of the countries that has the same problem. Some major cities in Indonesia experience forest fires every year, causing air pollution that is harmful to the population. Jakarta, the nation's capital, is the city with the worst air quality today. A significant contributor to air pollution is motor vehicle emissions (Kemenkes, 2023).

Poor air quality has a negative impact on public health. Acute respiratory disease is one of the consequences suffered by people affected by air pollution. Not only respiratory diseases, but air pollution also impacts life expectancy (Lee & Greenstone, 2021). Air pollution has reduced the life expectancy of Indonesians by 5.5 years for some cities with very poor air quality such as Jakarta and Kalimantan which often experiences forest fires. If Indonesia can reduce air pollution levels, as has happened in China, then people's quality of life will increase by about 1.9 years.

Air pollution is not simply solved by wearing masks when doing activities outside, but there needs to be a solution to reduce air pollution. Thus, air quality becomes good. Several solutions have been done to reduce this air pollution. One of them is the existence of air purifiers to produce clean air in the room. In this air purifier, many air filters have been developed that can filter air particulates of various sizes, one of which is fiber material as a HEPA Filter media (Beckman et al., 2023). However, this can only be used as a solution in a closed room, while for outdoor activities, of course, there needs to be a real solution, one of which is to reduce the

combustion emissions of motorcycles in Indonesia (Sengkey et al., 2011). One of the pollutants that is quite dangerous from motorized combustion emissions is carbon monoxide. For example, in one of the major cities in Indonesia, namely Manado, carbon monoxide (CO) levels from burning motorcycles throughout the day on average produced 15577.07μg/m3. This high CO level is very dangerous for the surrounding community. Therefore, there is a need for special handling to reduce this, namely by reducing motor vehicle emissions.

Reducing motor vehicle emissions is one of them by developing a filter for the combustion of fossil fuels in vehicles. Thus, the air coming out of motorized vehicle engines is not dangerous. There have been several studies related to air filters in motorcycles presented in Table 1.

The importance of developing filter research on motorcycles is to continue to be developed in Indonesia. This is because the majority of the Indonesian population uses motorcycles for activities, including students who are in high school. For high school-age children, modifying motorbikes is their pleasure. In Indonesia, motorcycle exhaust modification is a trend among high school students. This modification causes the burning of fossil fuels in motorcycles to become more dangerous. Therefore, high school students need to learn about air pollution and this is one of the goals of sustainable education (ESD). Many reports relating SDGs have been well-documented (Nurramadhani et al., 2024; Makinde et al., 2024; Hag et al., 2024). Several points are explained in SDGs:

(i) SDG3.9.1 on health to reduce the risk of death and disease due to air pollution,

(ii) SDG7.1.2 to ensure clean air in the house,

(iii) SDG 11.6.2 to reduce adverse environmental impacts by improving air quality (Sustainable Development Goals and Amp; Air Pollution, 2023).

Sustainable education has been included in the Merdeka curriculum (Susilowati et al., 2023; Fiandini et al., 2024). In grade 10, the science lesson contains learning outcomes for pollution problems. Even so, laboratory activities on air pollution have not been studied in depth. For this reason, it is necessary to study laboratory activities related to air pollution. Thus, students' process skills and attitudes towards sustainable awareness can be built early. In addition to process skills, this study is to introduce students to filters that can be made from natural fibers. Indonesia is rich in natural fibers and their utilization has not been maximized (Suriaman et al., 2022). This skill is indispensable, especially for vocational high school students. They need this knowledge. Thus, when they graduate from vocational school, they can apply their knowledge in the work field.

Teaching about pollution is a very crucial issue in Indonesia's curriculum nowadays which is called Independent Curriculum. The independent curriculum has integrated the curriculum with sustainable education to achieve the goals of UNESCO. This is important because this is a global problem that must be addressed together.

TABLE I
RESULTS OF NATURAL FIBER RESEARCH TO FILTER POLLUTANT LEVELS FROM MOTORCYCLE VEHICLE COMBUSTION

No	Title	Results	Reference
1	Effect of Modified Air Filter to Improve the Performance of 110 cc Matic Motorcycle	Research on the Honda Scoopy Fuel Injection 110 cc engine by varying the standard filter with gauze ram wire and the results obtained that testing without a filter achieved higher power and torque, namely 8.6 HP and 23.45 Nm when compared to standard filters and modified filters.	Permadi & Widodo, 2021
2	Effect of Air Filter Type on Injection System on Motorcycle Engine Performance Motorcycle Engine Performance	This research was conducted on a Honda beat injection motorcycle engine using a standard filter and racing filter. The results showed that the torque value increased by using a racing filter, namely 8.80Nm from 2 Nm by using a standard filter.	Riyanto Yanuar et al., 2023
3.	Coconut shells as filling material for anaerobic filters.	Filter was developed using biomass materials such as coconut fiber, DPF coco fiber, coconut skin, coconut skin carbon, and dust. The results of this filter research can reduce motorcycle particle emissions with efficiency using the technology developed. Porosity-based filters have a filter effectiveness of 27 to 10%, electrostatic-based filters have a filtration efficiency of 37 to 1%, and radiation-based filtration has a filtration performance of 27% to 42%.	Cruz et al., 2013
4	Developing fine particle filtering system for motorcycle exhaust using coco fibers	This research created a unique filtration system by combining cocoa fibers and lipstick tapioca in various ratios such as 50:50 (Filter 1), 60:40 (Filtro 2), 70:30 (Film 3), and 80:20 (Filter 4). Three different motors (M1, M2, and M3) were used to evaluate the filter efficiency. The filter efficiency was found to range between 12% and 33% depending on the filter thickness, density, and mix of fiber and spleen.	Wardoyo et al., 2019

The inclusion of air pollution topics in the science curriculum at vocational schools is very important and closely related to the lives of people today. Therefore, learning with a contextual approach will provide real experience for students as well as develop sustainable environmental awareness and improve students' critical thinking skills (Liu et al., 2017).

The problem of air pollution, especially that caused by motorcycles, is very close to the lives of students in Indonesia who often modify motorcycle exhausts. Thus, the resulting emissions are also greater and more dangerous. However, because the experiment for emission testing is not possible to be carried out in vocational schools due to the high cost of this experiment, there must be an experiment on air pollution. Thus, students understand not only limited to theory as shown in Table 2.

TABLE II
UPPER SECONDARY SCIENCE LEARNING OUTCOMES

Element	Learning Outcome
Explain phenomena scientifically	Learners are expected to understand scientific knowledge and apply it; or make simple predictions with evidence. Learners explain phenomena that occur in the surrounding environment from various aspects such as living things and their environment.
Design and evaluate scientific investigations	Learners can determine and follow appropriate procedures for conducting scientific investigations, explain the appropriate mode of investigation for a scientific question, and are expected to identify flaws or errors in the design of scientific experiments.
Interpret data and evidence scientifically	Learners can interpret data and evidence from different sources to build an argument and defend it with a scientific explanation. Learners are expected to identify correct conclusions drawn from tables of results, graphs, or other data sources. Learners plan and implement actions as follow-up, communicate the process and results of their learning, and self-reflect on the stages of the activities carried out.

Filters are one way to reduce the air pollution produced by burning motorcycles. One of the functions of the air filter is the effectiveness of fuel usage results, the filter saves fuel usage (Alexander, 2020).

The working principle of the filter is based on the classical theory of brown motion on particles. Particles move as a result of moments of inertia following the airflow. Particles that do not follow the airflow will be trapped in the filter due to the mass of the particles (Liu et al., 2017). According to its use, the filter is divided into an open system and a closed system. The air filter used for the cleanliness of the air produced from combustion, then using a replacement air filter that has more air supply, can be cleaned (Fuhaid, 2010).

To measure the air quality, Arduino is an open-source electronic device to makes it easier to use and the costs incurred tend to be cheaper (Prabowo & Irwanto, 2023). The parts of the Arduino Uno are microcontrollers as the main component. This component consists of a chip that processes Arduino programs both input and output. Arduino Uno is the most popular Arduino board powered by an Atmega 328 processor, 16 MHz, with 5V and 3.3 V power rails (Argadhia Hartono et al., 2020). The program was used by using the Arduino sensor 135 device in Figure 1.

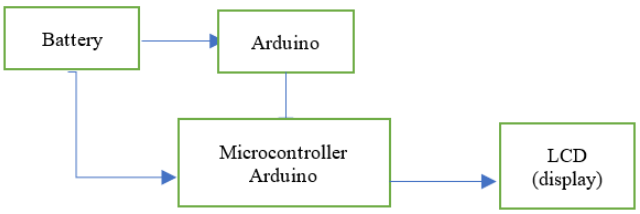


Fig. 1. Arduino Uno Device and MQ-135 Sensor

Contextual Teaching and Learning (CTL) is an approach to education that aims to connect classroom learning with real-life situations, thereby enhancing students' understanding and application of knowledge (Roopa, & Hunashyal, 2020). This approach is designed to improve students' higher-order thinking skills (HOTS) and self-efficacy by providing opportunities for them to analyze, evaluate, and create in authentic contexts (Alliyah, 2020). CTL is based on the idea that the mind naturally seeks meaning in context, and it encourages educators to create learning environments that incorporate cultural, physical, and psychological aspects to help students discover meaningful relationships between abstract ideas and practical applications (Sridharan, 2021).

The theoretical basis of CTL is rooted in the idea of teaching content in context, helping students make connections between knowledge and its applications to their lives as family members, citizens, and workers (Hudson & Whisler, 2007). This approach is grounded in brain research, which indicates that students learn best when they see the relevance of the content to their own lives.

The purpose of this study was to enhance students' understanding of air pollution through contextual teaching by conducting experiments that students can directly engage with. These experiments focus on using natural fiber filters to reduce air pollution from motor vehicle emissions, which are especially relevant to vocational students who often modify motorcycle exhausts, leading to more dangerous emission. The goal is to raise awareness about sustainable development and improve learning outcomes related to air quality and environment sustainability. The novelty of this study lies its development of an affordable and accessible experimental tool for air quality measurement.

To support the analysis was used SPSS. Detailed information regarding the use of SPSS is explained elsewhere (Fiandini et al., 2024). In the method section, several statistical tests carried out were explained.

II. METHOD

2.1. Designing the experiment set

The experimental set was made from recycled iron plat and natural fibers, namely: coir, palm fiber, pineapple fiber, and wood fiber The filters were made simply; weigh each fiber and cover it with the fabrics filter. Moving on from science learning in vocational school which aims to formulate ideas for solving environmental change problems

that occur in the surrounding environment, namely in overcoming air pollution problems, experimental tools are designed that are closely related to the vehicles used by vocational school students. The majority of vocational students use motorcycles. Thus, the tool is made to overcome the combustion products produced by motorcycle exhaust.

The tool is made using a recycled iron plate shaped like a cone with a diameter of 11 cm according to the average diameter of the exhaust of a motor vehicle and is shown in Figure 2. This plate is connected to a pipe to become a channel for combustion gases detected by an MQ 135 sensor that has been calibrated with an Arduino processor. The filter is made simply by using natural fibers, namely, coir, palm fiber, pineapple fiber, and wood fiber. This filter is packed using gauze with a thickness of 1.5 cm.

Fig. 2. Experiment Set.

2.2. Research Design and Teaching Approach

This study used a quasi-experiment, which is called one-group pre-test post-test design. The study was conducted at a Vocational High School in grade 10 with 31 students. The research in teaching and learning was carried out with the flow described in Figure 3.

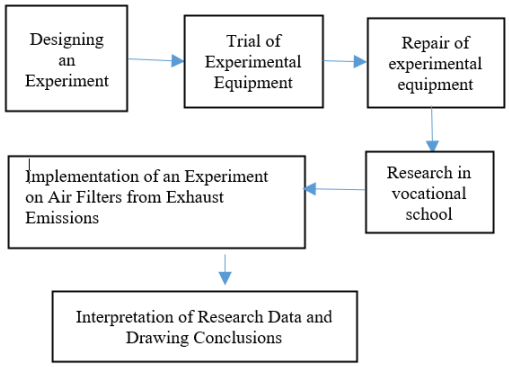


Fig. 3. Flow of Research.

2.3. Instrument Validity

Validity is an indicator used to evaluate the extent to which an instrument can measure the intended variable (Kimberlin & Winterstein, 2008). The validity of an instrument is measured based on its ability to accurately measure the variable. In the context of test testing, empirical validity often involves an assessment of the internal consistency of items as described by Long et al. (1985). Each item on a test instrument should be able to measure similar concepts and show a consistent pattern. This indicates that each item should have a positive correlation with the total score as expressed in Equation (1).

$$rxy = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2)(\sum X)^2 (N\sum Y^2 - (\sum Y)^2}} \quad (1)$$

Where :
N = number of samples,
X = item score
Y = total score,
rxy = correlation coefficient between item scores and total score

2.4. Reliability

A reliability test is a statistical procedure that is carried out to evaluate the consistency and reliability of a measurement instrument (Kimberlin & Winterstein, 2008). The main purpose of the reliability test is to ensure that the instruments used in research or measurement can provide consistent and reliable results. One of the commonly used reliability coefficients is the Cronbach Alpha coefficient. This alpha coefficient assesses the internal consistency between items in the instrument, namely the extent to which the items are related to each other and measure the same aspects of the variable being measured. The alpha coefficient value scale ranges from 0 to 1, and the higher the alpha coefficient value, the higher the reliability level of the instrument (Taber, 2018). With a non-dichotomous form of instrument (with a score range of 0-4), the internal consistency of the test (internal reliability of the test) can be calculated using the Cronbach Alpha coefficient formula as expressed in Equation (2):

$$\propto = \frac{n}{n-1}\left[1 - \frac{\Sigma\ Si^2}{Sx^2}\right] \quad (2)$$

Where:
α = Cronbach Alpha
n = number of items in the instrument
Si^2 = total item variance; the sum of the variances of each item in the instrument
Sx^2 = the sum of the variances of all items in the instrument

The reliability category according to Guilford (Shea, J. A., and Fortna, 2002) is in Table 3.

TABLE III
RELIABILITY CATEGORIES

Score	Categories
0.80 – 1.00	Very high reliability
0.60 – 0.80	High reliable
0.40 – 0.60	Medium Reliable
0.20 – 0.40	Low Reliable
-1.00 – 0.20	Not Reliable

2.5. Student's Misconception Analysis

The results obtained from students will be analyzed based on student answers. The data analysis technique of this result by the value on the CRI scale (Indrajatun et al., 2022) in Table 4. Detailed information for CRI is explained elsewhere (Putri et al., 2022).

TABLE IV
STUDENTS' MISCONCEPTION CATEGORIES

Scale	Category	Code
0	The whole answers are guessing	TS
1	Part of the answers are conjecture	SM
2	Not Sure	HY
3	Confirm	Y
4	Almost Understood	HP
5	Totally Understood	SP

Further analysis to distinguish between conceptual understanding, misconception, and not conceptual understanding for individual students consisted of the criteria presented in Table 5. Criteria for distinguishing conceptual understanding, misconception, and not understanding the concept for individual students (Putri et al., 2022).

TABLE V
CATEGORIES OF STUDENT ANSWERS BASED ON CRI

Criteria for answer	Low value of CRI (<2,5)	High-value CRI (>2,5)
Correct Answer	Correct Answer but low CRI <2.5 means no understanding of the concept only successful guessing (lucky guess)	Correct answer and high CRI mean good concept mastery
Wrong Answer	Wrong answer and CRI < mean not understanding the concept	Wrong answer but CRI > 2.5 means misconception has occurred.

2.6. N- Gain Analysis

The data of scores obtained from this research will be used to observe the individual changes in n-gain for each student. The N-Gain result is used to determine the significance of student learning outcomes between before and after learning after certain actions or treatments. The N-Gain test criteria are presented in Table 6.

TABLE VI
N-GAIN TEST CRITERIA

Limitation	Category
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Moderate
$g < 0.30$	Low

2.7. Test the Difficulty Level of Question Items

The difficulty level of a question item is determined by the percentage of students who answered it correctly. This analysis of difficulty was conducted using Robert L. Thorndike and Elizabeth Hagen's level calculations, and the outcomes are presented in Table 7.

TABLE VII
DIFFICULTY LEVEL OF QUESTIONS

Question Number	Difficulty index value	Question category
1	0.63	Medium
2	0.73	Easy
3	0.65	Medium
4	0.27	Hard
5	0.45	Medium

III. RESULTS AND DISCUSSION

3.1 Experiment Set

The results of fiber testing that have been carried out obtained the data presented in Figure 4. The results of the tool experiment show that wood fiber is most effective among coconut, pineapple, and palm fibers to absorb pollutants from combustion from motor vehicles. At the time of learning at school, students also obtained the same results as the results of the practical tool trials that had been made, although with different motor vehicles.

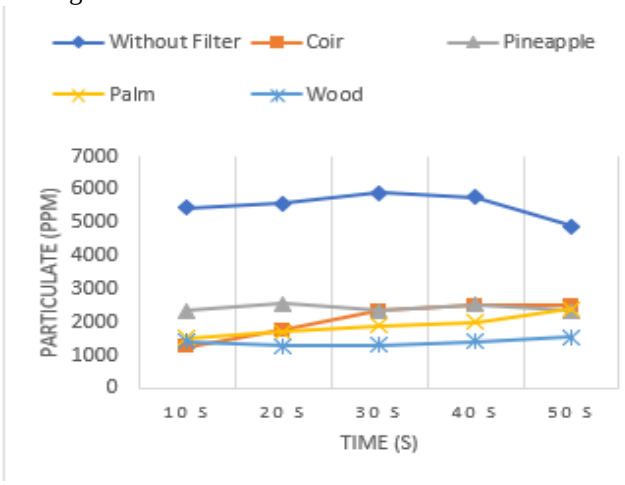


Fig. 4. Air Quality Graph with Natural Fiber

The results of experiments on air filter devices used in motorcycle exhausts found that wood fiber is the most effective of the three other fibers. This filter reduces the air pollution released by the combustion of motor vehicles, this is in line with teaching and learning that have been conducted to improve air quality in homes, the material for building the house is replaced with wood-based materials. Wood-based materials have been able to reduce particulate levels in the house by 12 µg/m3 (Cho, H. M et al., 2019).

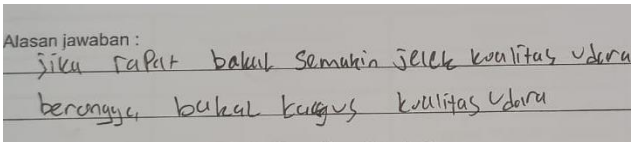
3.2 Learning Outcomes

Learning is carried out on grade 10 students, students are quite active during learning but are not accustomed to expressing opinions, this is very clear from the assessments given. Students have difficulty explaining the reasons for choosing the answers they have chosen. It can be seen from the examples of answers given by students in Table 8.

TABLE VIII
PERCENTAGE OF STUDENTS WHO WRITE REASONS

Questions	No reasoning	Wrong Reasoning	Correct Reasoning
1	9.68%	87. 09%	3. 23%
2	9.68%	67.74%	22.58%
3	25. 81%	54.19%	20.0%
4	82. 58%	10. 97%	6. 45%
5	6.45%	77. 42%	16.13%
Means	8.60%	67.74%	9.68%

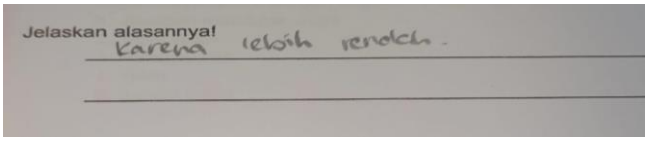
Table 8 shows that more than 50% of students were unable to provide correct reasons for the answers they had chosen, namely 67.75%. Only 9.68% of students were able to give correct reasons, which is a low percentage. Problem number 1 is a question about making a filter that can be used as an air filter. By experimenting, students should have observed and used an air filter, namely a filter that still has a cavity, following the concept of inertia that has been discussed in class. Students who answered correctly 63% of students but students cannot provide reasons for the answers that had been chosen. From the reasons written by students in Figure 5, students have difficulty explaining in detail. Even though the answer choices are correct, and have high confidence in the answers, students have quite low science literacy skills. The explanation written is not based on scientific thinking following the concepts that have been learned.



(translate: it is tight it will be bad while hollow will be good air quality)

Fig. 5. Answer Sample Question Number 1

Likewise, for question number 2.73% of students can choose the correct answer, but the reason for choosing the correct answer is only 22.58% students can provide the right reason. The interesting thing found in this study is that 73% of students answered correctly. There were 91% of students who wrote the reasons for the results achieved effectively. In this case, students can read the table presented and can choose the correct answer, but cannot put in writing the reason for choosing the correct answer as shown in Figure 6, one example of the reason written by students for question number 2.



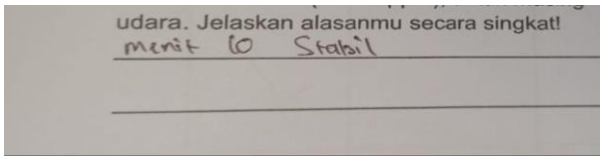
(translate: it is lower)

Fig. 6. Answer Sample Question Number 2

The reason written is only because it is lower, students do not explain further due to their limited science literacy. This is reinforced by the results of interviews with science teaching teachers. Vocational students are rarely given essay questions that require students to explain the answers given. Vocational school students mostly work on multiple-choice questions. In class learning, students directly practice/experiment following the practicum instructions that have been provided, because the goal to be achieved is that students can operate rather than analyze/apply the concepts that have been learned. The skills that vocational schools focus on are the skills to use tools following their respective fields, in other words as technicians.

Other results found through the assessment that has been given, students are very weak in the ability to interpret data. Problem number 4, is a problem that presents a graph to be interpreted by students and is expected to predict the air quality of certain fibers. For this question, only 16% of students were able to give the correct answer and only 6.45% of students answered correctly with the correct reasoning. The weaknesses that students have for this problem are related to the mathematical concept of presenting data in a graphical form that has not been mastered by students. Figure 7 clearly shows that students do not understand the meaning of the question and cannot interpret the data that has been presented.

Students have not been able to predict the results based on the data that has been presented. Of course, this is related to the basic math skills possessed by students. Science learning provided by each often emphasizes science concepts and does not integrate the concepts of other sciences, especially mathematics which is very close to science (Pendidikan et al., 2021).



(translate: stable in 10 minutes)

Fig. 7. Answer Sample Question Number 3

In addition, the results of the analysis for student misconceptions still show problems with the concepts that have been taught in Table 9.

TABLE IX
PERCENTAGE OF STUDENTS' CONCEPT UNDERSTANDING LEVEL

Questions	PK	PKKY	M	TK
1	35.48%	25.81%	25.81%	12.90%
2	45.16 %	29.03 %	19.25 %	6.45 %
3	25.81%	35.48%	29.03%	9.68%
4	3.22%	12.90%	32.26%	51.61%
5	12.90%	41.94%	35.48%	9.48%

Notes:
PK = fully understood the concept
PKKY = understood but not sure
M = misconceptions
TK = not knowing the concept

Misconceptions still occur among students after learning takes place. Students who understand the concept with the highest percentage is question number 2, which is 45, 16%. This question is understood by students after the motorcycle exhaust filter experiment is carried out. Students can apply and read the data that has been presented in tabular form. It is very visible in question number 4, as many as 51.61% of students cannot answer this question. Problem number 4 is related to the mathematical concept of presenting data in graphical form.

However, the results of the pre-test and post-test showed an increase. The data in Table 10 is the N-Gain data for improving student learning outcomes. The low category is 29% of students, and the medium and high categories are 35% of the total number of students.

TABLE X
N-GAIN PRE-TEST AND POST-TEST

Name	Pre-test	Post-test	N-gain	Category
Student #1	14	33	19	Low
Student #2	0	83	83	High
Student #3	14	67	52	Moderate
Student #4	0	83	83	High
Student #5	14	67	52	Moderate
Student #6	0	50	50	Moderate
Student #7	0	67	67	Moderate
Student #8	0	83	83	High
Student #9	0	83	83	High
Student #10	0	67	67	Moderate
Student #11	29	83	55	Moderate
Student #12	14	67	52	Moderate
Student #13	0	33	33	Moderate
Student #14	71	83	12	Moderate
Student #15	0	83	83	High
Student #16	71	100	29	Low
Student #17	57	70	13	Low
Student #18	29	100	71	High
Student #19	14	100	86	High
Student #20	0	100	100	High
Student #21	0	33	33	Moderate
Student #22	14	83	69	High
Student #23	14	83	69	Moderate
Student #24	14	50	36	Moderate
Student #25	71	100	29	High
Student #26	14	33	19	Low
Student #27	29	33	5	Low
Student #28	43	100	57	High
Student #29	43	57	14	Low
Student #30	57	83	26	Low
Student #31	14	57	43	Moderate
Mean	21	72		
Standard Deviation	22.82	21.67		

The increase in students' N-Gain is also in line with the descriptive statistical test, when the normality test is carried out, the results show that the data is not normally distributed. Therefore, the analysis was carried out nonparametrically with the results showing. The result of $p < 0.001$ indicates difference between the results of the pretest and post-test seen in Table 11.

TABLE XI
WILCOXON TEST RESULTS PRE - POST-TEST VALUES

Median (min-max)		P
Pret-test (n=31)	14 (0-71)	<0,001
Post-test (n=31)	83 (33-100)	

The improvement of students' learning outcomes was followed by a reflection conducted to see students' perceptions of the criteria of motivation, use of learning media, and students' attitudes towards sustainable education

(ESD). The data shows that these criteria are classified as moderate as shown in Table 12. Table 12 shows that some students have an understanding of sustainable education, especially in the problem of air pollution through experiments on filters used in motorcycle exhausts.

TABLE XII
STUDENT PERCEPTIONS OF LEARNING

Indicator	Mean	Category
Creating interesting and enjoyable learning	2,827586	Medium
Utilizing various learning resources	2,982759	Medium
Relate to real-life problems related to the environment	2,965517	Medium

CONCLUSION

Teaching and learning with a contextual approach that has been implemented can create quite interesting learning for students. Connecting the real problems in teaching and learning, especially the problem of air pollution has been able to integrate students' concern for the surrounding environment and at the same time concern for sustainable development. In addition, students have been introduced to the concept of handling air pollution through filters made from used materials and natural fibers that are easily found in Indonesia. Air quality measurement also uses Arduino Uno devices and MQ-135 sensors which are quite cheap compared to air quality sensors on the market. So, the cost of experiments conducted at school is quite cheap and affordable.

The learning that has been carried out has been able to improve student learning outcomes. Student learning outcomes have increased N-Gain for each student. Thus, students' scores in the pretest had a median value of 14, after learning the median post-test reached a value of 83. The non-parametric Wilcoxon test results also show a difference in pretest and post-test scores.

Although it has increased, learning still needs to be improved, especially in understanding the concepts of students. Thus, there are no student misconceptions about the concept of filters used for air pollution. Not only concept understanding, it is also necessary to study the science literacy and basic math skills of students that need to be improved to improve students' higher-order thinking skills.

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