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USE POLLUTION PATROL AS A DETECTOR IN ASSESSING THE SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) CONCEPT OF PARTICULATE MATTER

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Abstract

The purpose of this study was to construct a prototype that would detect air pollution and distinct microenvironments in the class. These include the characterization of observed outdoor air pollutants, source identification, detector designs, and mitigation strategies. The research method was the single subject of pre and post-testing the single subject of pre- and post-testing procedure. Many 112 second-grade junior high school students participated in the study. The student places the detector at 3 different locations around the school than using hand lenses, they analyze the particulates collected by their devices. The results were collected and then analyzed and accompanied by counting average the number of particles throughout 5 random squares. The simulations demonstrated that the proportion of pollution levels at contamination testing locations varies. The results also confirmed that the type of particulate pollution did students find the largest quantity are coarse particles (including smoke, dust, dirt mold, and pollen). It is because fine particles have a diameter of fewer than 2.5 microns and are much more difficult to trace. Furthermore, this research into the mitigation of outdoor air pollution through the development of designing pollution patrol detectors by students might enhance the mitigation knowledge. Thus, future research should concentrate on the analysis of developing the prototype for outdoor air contaminants, such as ultrafine and nanoparticles, and their health impacts.

Keywords: Design device, Detector, Pollution patrol, Particulate matter, STEM.

1. Introduction

Pollution patrol as a detector in assessing Science, Technology, Engineering, and Mathematics (STEM) concept is an alternative method for students to comprehend complicated ideas in science learning [1-2]. According to several studies, the STEM concept of air pollution has emerged as a significant problem and requires a solution in science education and the environment [3-4]. As a result, environmental awareness should be included in early education as a preventive measure in dealing with present environmental concerns including designing a pollution detector [5].

A study conducted in Indonesia provides student background on how to solve tests about air pollution detection using Project Based learning mode [6]. The study used the PISA instrument to identify the science literacy on air pollution [7]. The results show students have difficulties with real-world problems, indeed air pollution, and it is also hard for students to visualize it [8]. These circumstances necessitate that the instructor investigates various techniques of learning to enhance student understanding and activity. A similar study was also conducted on STEM activity practice regarding the scientific creativity on air pollution [9-10]. The findings of these studies demonstrated that students' scientific creativity was increased through those activities. However, the practices focused on calculating and interpreting arithmetic mean. These circumstances necessitate the teacher's investigation of potential methods to improve student STEM concepts and activity on air pollution.

According to prior studies, there has been no research on the concept of air pollution for secondary students, such as the use of a pollution patrol experiment detector. Although this air pollution issue is intriguing for discovering an appealing technique to reduce particulate pollution around their school using simple detector devices. The aim of this study was also to instill a STEM concept in students through a pollution patrol detector experiment related to the many factors that damage our lives as a result of air pollution impact. The focus of this research was to provide students with real activities through pollution patrol detectors. They have also contributed to relevant context and content about particular matters around. As a result, they may be able to create devices that indicate the existence of polluted air, build a simple detector, and finally test and calculate the final product.

2. Literature Review

Air pollution is described as the presence of pollutants in the atmosphere that might produce undesirable consequences for human life and the environment. It is a word used to define any undesired chemicals or other things that pollute the air we breathe, resulting in a deterioration in its life-sustaining properties (often referred to as air quality) [11]. There are specific sources of air pollutants that may be recognized, and these emission sources could be categorized as Natural (biogenic) and Man-made (anthropogenic) [12].

Figure 1 depicts the relative size of air particles (presently recognized by dots), as well as the distance between them, as well as the corners of colloidal nanoparticles' diameter ratio of 100 nanometers (0.1 um, representative of the total count intensity peak in automobile emissions), 500 nm (0.5 um, representative of the concentration method), and 5 um [13]. Solitary components are indeed meant to refer to those as molecules, and molecules are not normally considered particles except when they are grouped [14].

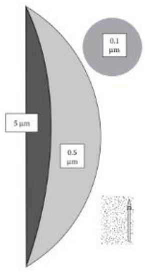

Fig. 1. The measure of air particles and the allow free path concerning particles of various sizes (adopted from the reference [14]).

The size distribution is said to be monodispersed when all of the substances inside a gas volume have the same circumference [12]. Monodisperse aerosols are indeed discovered when they are created synthetically for readjusting sampling devices; even then, they quickly become polydisperse because of collisions and agglomeration between initial particles [13]. Because these extremely Tiny particles have higher heat energies and quickly coagulate with others, Such an average diameter has a significant number density and a short retention duration [12]. This refers to the accumulation diameter mode, in which particle concentration levels tend to rise due to inefficient deposition [14]. Figure 2 describes the classic tri-modal size distribution these three mechanisms produce: crystallization, accrual, and structural production.

3. Research Methods

3.1. Research subject

A single-subject design was adopted in this investigation, using a pretest-posttest. The research included 112 students from the junior high school's second-grade class, comprising 76 female students and 36 male students. Their abilities and features also vary. The materials used in this experiment were of two types: building materials and testing materials. They were coffee absorbs, notecards, paper plates, tie-downs, disposable cups, microscopes, shears, double-sided tape, rulers, Karo sweetener, chains, hand lenses, petroleum jelly, and graph paper. It was dubbed a pollution patrol due to the method used. The equipment should be relatively protected from the weather and should be secure.

3.2. Materials and method

Initially, we recruited a group of students to experiment. We initiated by having students discussion on some pollution problems, how they believe it is assessed, how it affects society, examining why engineers create sensors to find the presence of various sorts of air contaminants. Students gathered to devise a strategy for their gadgets. They decided on the items they required, write or sketch the students' plan, and presented it to the class. Each team put its air pollution detector to the test by putting it in a different area throughout the school.

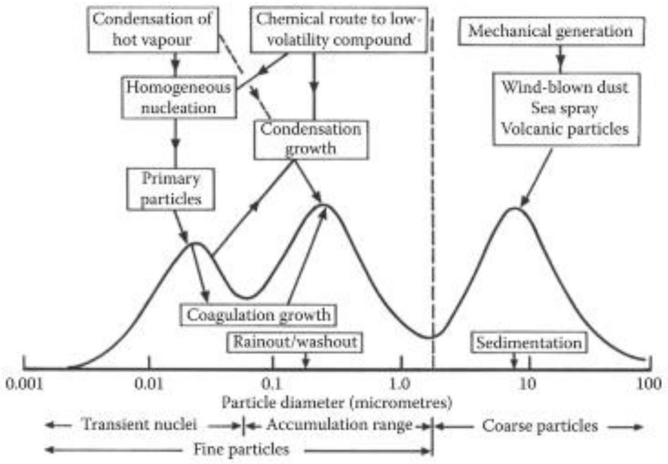

Fig. 2. The trimodal particle size distribution (adopted from reference [14]).

Students verify for signs that their particulate detector picked up certain particles after 72 h. To inspect the particles obtained, they used a hand lens, microscope, and digital camera. Teams recorded the many sorts of particles they noticed (e.g., dust, pollen, and dirt), as well as their size, color, shape, and texture. Then, using string, students form a grid of 1-cm squares over their device's collection area, fixing it with tape. Then, we asked students to count the number of particles in five random squares. If there are too many, we made a guess. We estimated the overall particle density per square. We made a comparison and diagram of the findings for the various locations analyzed in class. The grid form of the students' experimental challenge is shown in Fig. 3. Students created a scale to assess the pollution in public places examined surrounding your school. Students collected the cards and counted the number of particles found within each square on each index card with a magnifying glass.

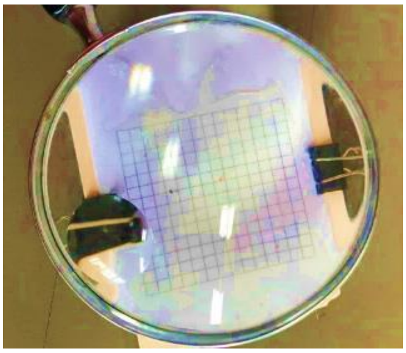

Fig. 3. Grid form of the experimental challenge.

4. Experiment results and discussion

In this laboratory challenge, students experimented with three different locations to figure out the number of air particles at each location over 72 h. Students must also identify the possible location of the experiment. Average particle per square relates to particulates, which is a solid particle mixture and liquid droplets that exist in the atmosphere but cannot be seen with the naked eye. Particulate matter is made up of PM2.5 and PM10, both of which are extremely dangerous and harm human health [15]. Figure 4 depicts one of the outcomes of calculating the average particle per square of students. This case was influenced by collection area and safety criteria, specifically maximizing flat area (at least, the size of 5 x 5 cm) and protecting from the elements and able to be secured (to keep it from blowing away).

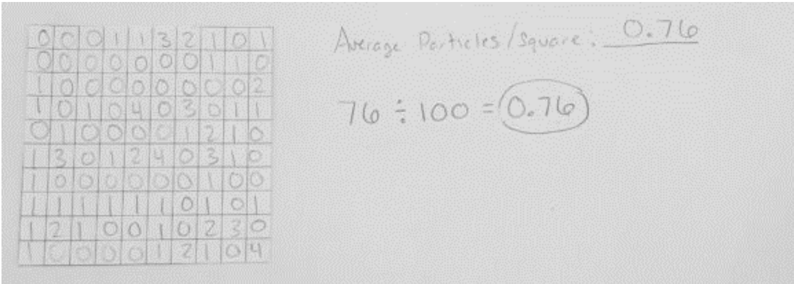

Fig. 4. Sample of students' calculating average per square picture

Table 1 shows the observations made by students who responded to the pollution patrol detector and design challenge test form. All students were successful in developing an air pollution detector capable of detecting the presence of particles in the air. Three types of collection areas are the backyard, parking area, and canteen. The average number of air particles is less than 2.5 um in all locations. Parking area or location 2 is the highest average number of particles found for 72 h. While at location 1, the result is lower than location 1 (back yard). On the other hand, the trend of air particles is less than 0.5 in location 3. The fluctuation of air particle values occurred in all locations. Based on all of the observations and data collected, the possible health location in there is location 3 (canteen). Emissions from gasoline, diesel fuel, or wood combustion contribute to the value. Location 2 can be represented by the highest pollutant area. Because parking areas emit a variety of hazardous gasses with very fine particles. As previously stated, smaller particle sizes are extremely hazardous to all forms of life, particularly people in school. The most effective way to reduce our exposure to the harmful area is to install at least one air filter in each area of the school.

Table 1. Measurement result for pollution patrol design challenge test form.

Criteria and Group	The average number of particles found in each square for different area			The average number of particles in all area
	Back yard	Parking Area	Canteen	
Group 1	0.76	0.85	0.36	1.97
Group 2	0.65	0.89	0.41	1.95
Group 3	0.61	0.75	0.48	1.84
Group 4	0.76	0.88	0.33	1.97
Group 5	0.70	0.89	0.45	2.04
Group 6	0.55	0.91	0.48	1.94
Group 7	0.87	0.82	0.31	2.00

Group 8	0.65	0.85	0.36	1.86
Group 9	0.80	0.81	0.54	2.15
Group 10	0.57	0.78	0.42	1.77
Group 11	0.62	0.75	0.37	1.74
Group 12	0.67	0.86	0.33	1.86
Group 13	0.81	0.93	0.42	2.16
Group 14	0.56	0.78	0.36	1.70
Group 15	0.63	0.83	0.39	1.85
Group 16	0.72	0.88	0.41	2.01
Group 17	0.76	0.79	0.45	2.00
Group 18	0.81	0.89	0.47	2.17
Group 19	0.63	0.89	0.38	1.90
Group 20	0.67	0.78	0.35	1.80
Group 21	0.62	0.81	0.41	1.84
Group 22	0.76	0.85	0.32	1.93
Group 23	0.55	0.72	0.39	1.66
Group 24	0.87	0.89	0.46	2.22
Group 25	0.53	0.81	0.49	1.83
Group 26	0.63	0.89	0.43	1.95
Group 27	0.68	0.84	0.47	1.99
Group 28	0.72	0.87	0.34	1.93

The results were significant after the test (see Table 2). The student enhanced his STEM concept about particulate matter. The accurate calculation and method of pollution patrol experiment from the point of view of detecting the presence of particles in the air. Furthermore, students have seen how essential it was to consider the pollutant and its impact. The results indicate that over students comprehend the STEM content completely. Furthermore, STEM learning through pollution patrol experiments and student design devices is the most encouraging teaching and learning innovation, particularly for preparing students to hone higher-order thinking skills and attracting students' interest in learning, both of which are critical in adapting to a competitive era [16, 17].

Table 2. Pretest-postest result.

Question	Pretest	Posttest	Gain
1. Were you successful in developing an air pollution detector capable of detecting the presence of particles in the air? If not, what went wrong?	78.50	88.90	22.20
2. Did you decide to change your original design or request additional materials while the project was being built? Why?	88.50	100.00	22.13
3. Did you make any component purchases with opposing teams? How did you find the process?	65.50	100.00	11.10
4. What materials would your team have requested unless you have gotten materials other than those provided? Why?	77.50	88.90	11.03

Question	Pretest	Posttest	Gain
5. Do you believe that engineers must modify their initial intentions while building devices or products? Why would they?	76.50	77.78	11.08
6. How would you change your planned design if you had to do it all over again? Why?	88.00	100.00	22.13
7. What designs concept did you find other groups try that you thought worked well?	88.00	100.00	11.10
8. Explain why do you believe this project more quickly if you worked alone?	76.50	100.00	0.00
9. What kind of particle matter did you encounter the most? Why do you think that?	77.00	88.90	11.03
10. What do you think can be done to reduce particulate pollution in the environment?	88.50	100.00	11.10
Rate	81.15	94.48	12.19

5. Conclusion

The experiment about pollution patrol was able to build students' STEM concepts. All students had the option of learning techniques enjoyable and accessible. The approach of the pollution detector challenge has been demonstrated to enhance students' STEM concepts. The findings also confirmed that the type of particulate pollution found in the greatest quantity by students is coarse particles (including smoke, dust, dirt mold, and pollen. The students were able to connect the technique of the modified experiment with the understanding of STEM concepts that primarily affect a new awareness of pollution and health risk.

Acknowledgments

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