Material development for environmental education

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Abstract. Garbage is a real enemy to the government and society. The number of floods in the area around the river Citarum, West Java, Indonesia, a periodic disaster that always occurs in the rainy season is believed to be caused by the amount of waste into the river. Lack of understanding of the community around the river, bad waste management, and the lack of waste processing equipment are heap factor in the river Citarum. This research uses research and development methods to develop project-based teaching materials with science, technology, engineering, and mathematics approach in environmental education. Material for environmental education has been developed through experiments by burning several types of garbage and measure the carbon monoxide it produces. The result of this research is the model of environmental education in handling garbage with project-based-learning model for elementary school student teachers.

1. Introduction
Garbage is a real enemy for the government and society. Lack of community participation in waste management is the most crucial obstacle in managing waste problems. Problems in urban waste management do not only occur in big cities but also occur in small towns and districts that have high enough density and high economic activity. Likewise, on campus, the campus environment is also inseparable from garbage problems. Therefore, a coaching model is needed for students, who embed their curriculum or through a project in environmental education so that students have sufficient care and knowledge for themselves and agents of changing community knowledge in managing and coping.

This study presume that the approach that can overcome this problem is the approach of Science, Technology, Engineering and Mathematics (STEM). Through this approach, students will integratively build knowledge comprehensively through knowledge of mathematics and science. Learning with the STEM approach can attract students’ interest in Natural science lessons and provide a deep understanding of essential concepts and learning. Students can learn important concepts (scientific knowledge), as well as relationships and their application in daily life [1].

Moreover, by analyzing phenomena and making solutions, students are also trained to explore and improve the STEM concept which will be useful for the future related to the many future needs that cannot be separated from science, technology, engineering, and mathematics. STEM is very suitable with the 2013 curriculum that is being applied in Indonesia. This approach will be more appropriate in primary schools because the effect is higher when compared to secondary and high education. However, this approach is also feasible at any level because it is student-centered and can activate students. The STEM approach to elementary school students can build concepts, theoretical frameworks with the Rube Goldberg engine applied in elementary school learning to enhance student creativity [2–5].
However, the studies above have not touched the realm of environmental education as part of education that is very influential in life of the community in society, which in fact has many problems such as garbage, floods, landslides and other disasters caused by human behavior. Based on the reason, this research will use research and development methods to develop project-based learning materials with a scientific, technological, engineering and mathematical approach environmental education. The purpose of this study is to develop the learning material based on managing garbage with project-based-learning model.

2. Methods
This research approach uses Research and Development, which intends to develop project-based learning using science, technology, engineering, and mathematics approaches. This research is a planned study of a problem using systematic methods and steps. The procedure adopted in this study is following the approach as in research and development (R & D) [6]. Research and development (R & D) according to Borg and Gall that [6]:

Research and development is an industry-based development model in which the research findings are used in the field of tested, evaluated and refined until they meet specified criteria of effectiveness, quality, or similar standards.

The research, designed with an R & D approach, as Borg and Gall argues, is "a process used to develop and validate educational products." [6]. This understanding implies that the method of research and development in the field of education is in principle a process for developing a research product, and then validating the product. This means that research and development methods are applied to produce products and test the effectiveness of products.

In the context of this research, the research products that will be developed and validated are teaching materials for learning STEM-based environmental education. The development of learning will use the theme of waste which is the primary cause of flooding in the Citarum area, West Java, Indonesia. Trash is not only a problem in the Citarum area but almost in various places. Researchers take several types of waste that will be used as research as the main problem in environmental education. To integrate it with other fields, this study will conduct a study on waste processing. The main focus of this research is how rubbish should be managed. Therefore, the types of waste will be burned and calculate the level of carbon monoxide (CO). Based on the burning of these types of waste, CO measurements will be measured per 10 seconds. Then the data will be processed, and the mathematical modelling of the CO produced.

Based on the results of mathematical studies, the appropriate technology will be formulated to process these types of garbage. The experiment was conducted to determine the amount of Carbon Monoxide (CO) in the combustion of waste. The waste used is garbage that we usually encounter around the environment. There are 15 types of waste used in the experiment this time: Banana leaves, HVS paper, plastic, cardboard, newspapers, styrofoam, weeds, teak leaves, Angsana leaves, straw, palm leaves, tissue, mango leaves, mahogany leaves, and leaves coconut.

The tool to measure CO levels in waste combustion results is a CO Detector. In the CO Detector tool, there is no interval to find the lowest to highest value category of CO. For this reason, the researcher determines the CO content from the waste combustion result by calculating the quartile of the numerical data that has been obtained. These numbers are obtained per 10 seconds when burning garbage.

3. Result and discussion
Carbon monoxide (CO) combustion of 15 types of waste is shown in table 1.

Table 1. Carbon monoxide combustion result.

| No | Kind of Garbage | CO result (in 2 minutes) |
|----|-----------------|-------------------------|
|    |                 | 10' 20' 30' 40' 50' 60' 70' 80' 90' 100' 110 120' |
| 1  | DP              | 27 47 191 270 460 334 237 185 200 215 199 235 |
| 2  | HVS             | 27 64 71 143 257 253 253 253 253 137 112 |
Carbon monoxide (CO) can be bonded in maternal hemoglobin, resulting in a fast-acting poison. This gas is colorless, odorless, flammable, used in the manufacture of various organic and inorganic compounds.

Through research that has been done, that is known which wastes produce high CO levels after going through the combustion process. Moreover, after researching plastic waste, it produces the lowest CO levels. Following Damanhuri's and Padmi statement that an understanding of waste segregation in daily activities is needed, so that people can sort out which trash can be recycled and reduced [7]. So that it can be minimized CO levels produced by burning trash, and obtained an alternative to processing waste in the form of leaves.

Based on the table above, the researchers tested 15 different types of waste, but only 12 types of waste were burned correctly. Three types of waste that are difficult to burn are leaves of manga, mahogany leaves, and coconut leaves. A group of waste that has a low CO content is a plastic with the highest combustion result 66 ≤ K1 = 111, the group of waste that enters the medium category is banana leaves 460 ≥ K1 = 111 ≤ K2 = 514.25; HVS 253 ≥ K1 = 111 ≤ K2 = 514.25; Styrofoam 124 ≥ K1 = 111 ≤ K2 = 514.25 and straw 466 ≥ K1 = 111 ≤ K2 = 514.25; while the group of waste that belongs to the high category is cardboard 683 ≥ K3 = 514.25; Newspapers 890 ≥ K3 = 514.25 weeds 670 ≥ K3 = 514.25, teak leaves 876 ≥ K3 = 514.25, Angsana leaves 608 ≥ K3 = 514.25, palm leaves 1708 ≥ K3 = 514.25. The lowest CO content is produced by plastic, while palm leaves produce the highest CO content. There is a repetition of newspaper burning because at the beginning the combustion results are affected by the rest of the previous combustion.

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Table 1. Cont.

|   | P   | 42 | 66 | 67 | 60 | 54 | 59 | 60 | 60 | 36 | 29 | 30 |
|---|-----|----|----|----|----|----|----|----|----|----|----|----|
| 3 | KAR | 57 | 75 | 101| 281| 489| 487| 560| 667| 615| 318| 287| 683|
| 4 | KOR | 202| 257| 406| 457| 890| 876| 847| 833| 880| 810| 774| 673|
| 5 | S   | 62 | 78 | 81 | 78 | 87 | 87 | 90 | 81 | 124| 120| 107| 112|
| 6 | RL  | 317| 670| 550| 519| 451| 456| 423| 335| 270| 290| 254| 203|
| 7 | DJ  | 100| 97 | 121| 147| 169| 342| 515| 727| 876| 617| 575| 499|
| 8 | DA  | 31 | 48 | 126| 514| 608| 401| 419| 273| 197| 169| 152| 131|
| 9 | J   | 50 | 126| 229| 269| 309| 405| 414| 466| 420| 279| 329| 296|
| 10| DPL | 117| 564| 246| 259| 1702| 1703| 1704| 1705| 1707| 1708| 1152| 988|
| 11| T   | 269| 257| 328| 509| 567| 644| 636| 581| 507| 551| 518| 479|
| 12| DM  |   |    |    |    |    |    |    |    |    |    |    |    |
| 13| DMH | UNBURN |     |    |    |    |    |    |    |    |    |    |    |
| 14| DMH | UNBURN |     |    |    |    |    |    |    |    |    |    |    |
| 15| DK  | UNBURN |     |    |    |    |    |    |    |    |    |    |    |

DP = banana leaves, HVS = HVS papers, P = plastic, KAR = cardboard, KOR = newspaper, S = styrofoam, RL = weeds, DJ = teak leaves, DA = Angsana leaves, J = straw, DPL = palm leaves, T = tissue, DM = Mango Leaves, DMH = mahogany leaves, DK = coconut leaves

From the numbers that have been obtained, then find the quartile value. Quartile values are obtained as follows: K1 = 111, K2 = 269, and K3 = 514.25. The lowest grouping of waste that falls into the CO-producer category if the combustion results are ≤ K1, the waste that enters the medium category when the CO combustion results are ≥ K1 ≤ K2, while the waste that enters the high category when CO ≥ K3 is combusted.
With this, we can use a wise way to process the garbage around our environment. Moreover, knowledge about waste management can be applied to children from the earliest possible time. Teach them by sorting trash by type. So that habits like this can be carried into adulthood and become a character that is firmly embedded in the child. As stated by Mulyasa that character is a distinctiveness in each, to be able to build character, a lengthy process is needed, one of which is through character education [12].

The data of the combustion test results will be associated with mathematics through mathematical modeling. Some graphs generated from the data above are shown in figure 1.

![Figure 1. Math Modelling on CO of burning DP, HVS P, and KAR.](image)

Environmental education based on the data above can be done through project-based learning. Project-based learning (PBL) is an innovative learning approach that implements a variety of strategies that lead to increasing 21st-century skills. PBL is a learning approach that is controlled by students through teacher assistance. In this case, students gain understanding through questions that can answer their curiosity [13].

PBL has a variety of objectives including the development of positive student attitudes, critical thinking skills, cooperation, and independent learning abilities [14]. In this case, students are stimulated to use critical thinking skills that will help them in building a learning community that masters collaborative learning content. With the implementation of PBL, students are provided with life skills that will be useful for their future life, in this case about waste management. Students can be asked to do the same experiment as the researcher did. Make the modeling, look for descriptive statistics or make mathematical modeling by using technology such as using MS Excel or SPSS. Furthermore, in groups of students, conclude which garbage should not be managed by burning. Then in the final section students plan a simple waste processing tool for the most carbon monoxide-producing waste.

4. Conclusion

Integrated environmental education with the other lessons is appropriate given to students to enhance their skills so they can solve problems and compete in the 21st century. The results of this study shown that many phenomena surrounding the environment can be related to other subjects, as well as some studies related to STEM, Chemistry learning in secondary schools, and in training institutions for disaster mitigation in border areas. Therefore, it is necessary to conduct other studies that can produce teaching materials that connect environmental education with mathematics, technology, and engineering and provide solutions to problems in the community that is related to the environment.
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