Utilization of Virtual Laboratory "Calculation of Motor Vehicle Exhaust Emissions" to Study Air Pollution

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Abstract. Air pollution is a crucial problem that must be minimized because air is a major component in life. One of the causes of air pollution is the result of exhaust gas emissions from motorized vehicles. Therefore, calculating motor vehicle exhaust emissions is one of the important things that students must master to foster environmental awareness. Efforts to make mathematical learning of the calculation of exhaust gas emissions interesting and fun, namely by using virtual laboratory media. In this case, discussed how the virtual media packaging Laboratory "Motor Vehicle Exhaust Emission Calculation" to study Air Pollution

1. Introduction
The development of private vehicles is currently centered on the number of vehicles, both cars, and motorbikes. According to the Indonesian Motorcycle Industry Association (AISI), the development of motorbikes circulating in daily life provides information on the growth in motorcycle sales which is in a high-value position, namely in 2012 there were motorcycle sales which touched a value of 7,064,457 units and in 2013 it is predicted to increase to 9.2 million units [1], and according to BPS data, the number of motorcycles circulating in Indonesia is 92,665,814 units [2].

The increase in the number of motorized vehicles is the biggest contributor to changes in air quality. Changes in air quality occur because motorized vehicles emit and pollute the air. Environmental Management Agency of DKI Jakarta state that air quality changes due to air pollution or changes in the composition of the air from normal conditions due to the presence of pollutants (in the form of gases and small particles/aerosols into the air in a certain amount that exceeds normal limits for a long time so that it disturbs the life of humans, animals, and plants [3].

The air pollution problem is a problem that must be minimized, by raising environmental awareness because air is an important component of life. One of the ways to raise environmental awareness is by integrating it in learning, for example, Science, Biology, or the chapter on exhaust emissions on Automotive Motorcycles in SMK. Widowati states that the strongest effort to overcome the challenges of the environmental crisis is through education [4]. Good environmental management can guarantee the availability of natural resources which are important for the welfare of the community. Future generations (read: students) need to be provided with provisions and insight into the environment.

Calculating the number of exhaust emissions is important to learn through interesting media so that students can understand and apply the knowledge learned in everyday life. Interactive media that can be used as an option is a virtual laboratory. This is important to review so that the mathematical calculation of exhaust emissions becomes interesting, fun, and interactive. In this paper, it discusses
how the development of a virtual laboratory in studying Air Pollution is reviewed with "Exhaust Emissions".

2. Discussion

2.1. What is the reason for the topic of exhaust gas emissions in studying Environmental Pollution?

The growth of motorized vehicles in Indonesia is very fast, as revealed in the research of Ismiyati, Marlita, Saidah that the increase in the number of motorized vehicles has reached 30%, and around 70% are distributed in urban areas [5]. The existence of this surge can cause changes in air quality to decrease. This is because motorized vehicles produce emissions, which are a contributor to air pollution that can have an impact on human health and the surrounding environment.

However, it seems that controlling air pollution will face obstacles given the rapid increase in the number of motorized vehicles. The data on the number of motorized vehicles in Indonesia from 2011 to 2013 are as shown in Table 1 [5].

| No | Transportation type       | 2011   | 2012   | 2013   |
|----|---------------------------|--------|--------|--------|
| 1. | Passenger car             | 8540   | 9525   | 10540  |
| 2. | Bus                       | 1920   | 1945   | 1965   |
| 3. | Vehicle                   | 4257   | 4723   | 5165   |
| 4. | Motorcycle                | 69205  | 77756  | 86253  |
| 5. | Ransus (special vehicle)  | 271    | 280    | 288    |
|    | Total                     | 84193  | 94229  | 104211 |

Motorized vehicles become a mobile source of exhaust gas emissions as a result of the combustion process in the engine room. Exhaust gas or emissions are defined as the result of burning fossil fuels such as coal, natural gas, and oil which are dispersed into the air, depending on the fuel composition and the type and size of the boiler. Every motor vehicle has exhaust gas emission standards. Exhaust gas emission-quality standards are the limits or levels of substances and / or components that are tolerated in emissions. The quality standard of exhaust gas from motorized vehicle sources is the maximum limit for substances or pollutants that can be directly removed from the exhaust pipe of motorized vehicles.

Exhaust gas emissions are in the form of exhaust fumes as a result of incomplete combustion and contain lead, suspended particulate matter (SPM), nitrogen oxides (NOx), carbon monoxide (CO), photochemical oxides (Ox) [3]. Furthermore, because the most significant exhaust gas from motorized vehicles to the atmosphere based on mass is CO₂ produced from complete fuel combustion which can be achieved by the availability of an excess air supply, this paper emphasizes the calculation of exhaust gas emissions in the form of CO₂.

The exhaust emissions generated in 2030 based on the Business As Usual (BAU) scenario are 21,700 metric tons of Non-Biogenic Carbon Dioxide, 100 metric tons of Carbon Monoxide, 300 metric tons of Nitrogen Oxides, 100 metric tons of Non-Methane Volatile Organic Compounds, and Carbon Monoxide and Non-Methane Volatile Organic Compounds whose value is very small under 6 metric tons [6].

2.2. What is the reason for the choice of media in the form of a virtual laboratory?

A virtual laboratory is included in computer-based multimedia. However, the use of multimedia has not been optimized, even though by using this multimedia there are many advantages, namely the resulting media can be made as desired. Virtual laboratories are a series of computer programs that can visualize abstract phenomena or complex experiments carried out in real laboratories so that they can increase learning activities to develop skills needed in problem-solving [7].

A virtual laboratory is an option because the media can combine animation, sound, images, graphics, audio, video in one medium which makes the learning media developed varied, not boring, interesting,
and makes it easier for students to understand the material. Another advantage of this multimedia development is that it is more flexible because it can be developed according to the wishes of the manufacturer, and can be used repeatedly because it is a computer soft file. Of course, this condition is important so that students are interested in learning. Sardiman states that if the use of learning approaches or methods is carried out correctly and can foster interest in learning, it is hoped that the quality of learning will be carried out well [8].

Saleh, Mohamed & Madkour revealed that virtual laboratories in the world of vocational education have easy access to engineering applications at any time and from any computing environment [9]. A virtual laboratory is an interactive learning environment, consisting of simulations, demonstrations, and exercises, which can fulfill the role of bridging from passive learning to active learning and thus stimulate deeper thinking. It is also very important to link theory to practice so that students can develop assessment techniques and understand how to process behavior can be captured using compelling mathematical models.

Kaylor & Thiruvathukal state that virtualization technology can deploy a new machine image to other machines on the network, even when the old machine image is being used: after the new image is applied to the target machine (or after the current user exits), it can simply boot a new picture [10]. It only costs downtime which is the shutdown and starts time for the old and new image machines, which is still a lot shorter than the time it takes to write a new image to the hard disk with conventional machine imaging because the machine can still be used during the imaging process. Another improvement over conventional machine imaging is the ability for multipurpose machines and better support user base with different requirements. With technology virtualization, we can apply several different images to a single machine.

2.3. How is the virtual laboratory media packaging developed?
Virtual laboratory media packaging to teach "Calculation of Motor Vehicle Exhaust Emissions" for Learning Air Pollution using the ADDIE Step (Analysis, Design, Develop, Implementation, and Evaluation).

2.3.1. Analysis
a. Needs analysis, shows that learning mathematics lectures are less attractive to students.
b. Content Analysis, which begins with analyzing the content of subjects containing exhaust gas emissions and will be integrated using a virtual laboratory.
c. Analysis of Learning Objectives, determine learning objectives
   The learning objectives that can be formulated include:
   1) Through a survey simulation activity using a virtual laboratory, students can measure the number of emission results from several types of motorized vehicles correctly.
   2) Through the use of a virtual laboratory, students can correctly relate the relationship between the number of vehicles and the number of emissions in the atmosphere.

2.3.2. Design
a. Formulating development objectives, among others: (1) the developed learning media can overcome difficulties in the learning process, namely limited time, space, sensory power, and weather conditions; (2) Virtual laboratory learning media can facilitate differences in student learning styles because it combines audiovisuals, (3) virtual laboratory learning media with inquiry approach can improve students' analytical skills; (4) Virtual laboratory learning media can make it easier for students to carry out experimental activities.
b. The use of products, this media is designed as a medium that can be used by students individually, so that all students get the opportunity, experience, and knowledge
c. Preparation of Material Concepts
d. Compilation of Media Forms Audio-visual media developed in the form of a virtual laboratory has several advantages, including practical, interesting, and interactive.

2.3.3. Develop
a. Making the script format (flow chart, storyboard)

The making of this script format begins with making a flowchart flow and is developed by making storyboards and drafts using PowerPoint slides, this aims to create a picture of the display form in each frame in the virtual laboratory and make it easier to work on learning media.

| Content in each view of each page | Background |
|----------------------------------|------------|
| An activity I, contain:          | Musical instrument "Prontera Ost Ragnarok Theme" |
| 1. Title of activity             |            |
| 2. A graphic image appears between the temperature increase and the increase in the CO2 exhaust gas |            |
| 3. Introduction to problems that students have to solve |            |
| 4. Objectives and formulation of experimental problems I |            |
| 5. Literacy studies              |            |
| 6. Variables and experimental hypotheses I |            |
| 7. Grouping of vehicles by type  |            |
| 8. Collecting data on vehicle types from 5 houses |            |
| 9. Vehicle emission calculator   |            |
| 10. Problem activity I           |            |
| 11. Conclusion                  |            |

b. Making Virtual Laboratory Product

Virtual laboratory products are developed with several page views, which include menus, instructions, basic competencies, materials, activities, profiles.

Fig 1. Menu page
On this page, problems are arising, which later this problem must be proven by students through activity I, and used by students in formulating problems. In this case, the ability that is raised is analytical skills, especially connecting.

In this media, because of the guided inquiry approach, the problem formulation in this activity has been provided, but in practice, the teacher must be able to lead students' thinking in formulating problems, based on existing problems and learning objectives so that students know what will be learned through activities I

This page is a page that students use to form the knowledge needed to complete the experiment. These questions are related to experiments in a virtual media laboratory. Figure 4. Literacy Study Activity I on this page students are directed to make hypotheses, based on knowledge and literacy studies. Figure 5. Activity Variables I on the page above students are directed to explore inactivity I, the direction of activity I consist of 3 frames, a frame I am explaining the activities that students must do, the second explanation of
gases produced by motorized vehicles, and the last is the grouping of motorized vehicles based on their types. The three frames are as follows:

Fig 5. Hypothesis statement page

At this stage of grouping, students are given knowledge of vehicle grouping based on their types. These 108 groupings are used in activities to be carried out, namely counting the number of vehicles in 5 houses. This is because new and old cars have differences in producing emissions. In the first experiment, students had to record the number of vehicles in the five houses, which later analyzed the CO$_2$ emissions produced by these vehicles.

Fig 6. Five houses as an observation object

The next step is to list the kind of vehicle in each house

Fig 7. The kind of vehicles in house A as an observation object

On this page, students are directed to count the vehicles in each house by writing down the number of vehicles for each house and classifying them according to their type in the boxes provided.
The next activity is for students to calculate the emission produced using an emission calculator, these calculations are carried out one by one. Initially, students are given a formula that can be used in calculating vehicle emissions, which is equipped with supporting information to calculate the number of emissions produced by several motor vehicles. Then the students calculate the emissions based on the formula previously presented. As follows:

These calculations are carried out one by one depending on the type of vehicle, then the students enter the calculation results into the table provided, and add them up so that the overall emissions are obtained. In the next activity, the students answered questions in the media, which amounted to 6 questions. And the last is to conclude the activities carried out by students.
c. Validation of Virtual Laboratory Learning Media

The validation of learning media is a stage where the media is assessed by expert lecturers based on the truth and feasibility of the learning media being developed.

2.3.4 Disseminate

This stage is the last stage that is carried out after the product being developed has been tested in the field and has been revised again. Products disseminated to target users.

If the problem when using a virtual laboratory is that students are still confused about their steps because there are no detailed steps in the virtual laboratory, the results of virtual laboratory calculations cannot be saved in pdf form, information on emission calculators and calculators on different slides so they have to go back and forth in calculating.

The follow-up is to provide detailed steps in the virtual laboratory, setting up the results of virtual laboratory calculations to be saved in the form of a pdf, information on the emission calculator, and calculator on the same slide.

3. Conclusion

The development of a virtual laboratory in studying air pollution focused on calculating exhaust emissions is important because it can increase students' knowledge and awareness of the impact of using motorized vehicles in contributing to air pollution, and can provide students with real learning experiences from the environment around students (contextual learning).

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