



Developing the Smog Problem in Indonesia STEM Education Learning Activity

Anggiyani Ratnaningtyas Eka Nugraheni

Faculty of Education, Khon Kaen University, Thailand
 Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia

Chokchai Yuenyong*

Faculty of Education, Khon Kaen University, Thailand

*Corresponding author email: anggiyaniratnaningtyas@kkumail.com, ychok@kku.ac.th

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Abstract: The paper will clarify the learning activities which provide through Sutaphan and Yuenyong (2019) context based STEM education learning approach. This learning approach consists of 7 stages including (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage. This learning activity will generate students to practice integrated knowledge among chemistry, biology, mathematics, art, and economics in order to design their products of air purifier as one of the ways to deal with smog problem in Indonesia. This learning activity may have implication for organizing STEM education in school setting.

Keywords: STEM education, learning activity, smok problem

1. Introduction

The educational sector responds to 21st century challenges by making 21st century skills as a general goal of education. Several developed countries have carried out various innovations to generate 21st century skills-oriented education. United State for instance, developed STEM education as a form of 21st century skill-oriented education. STEM stands for Science, Technology, Engineering, and Mathematics. STEM was launched by the US National Science Foundation in the 1990s as the theme of the education reform movement in the four disciplinary fields to enlarge the workforce in STEM fields, as well as to enhance populations who are STEM literate. Furthermore, these education reforms also aim to increase US global competitiveness in science and technology innovation (Hanover Research, 2011).

Nowadays, STEM is adopted by various countries including Indonesia. To respond to global competition, Indonesia must prepare qualified human resources in STEM disciplines with enough. Based on data from the Central Statistics Agency in 2010, Indonesia's human resources are still dominated by unskilled labor (as many as 88 million), and it is predicted that by 2020 there will be a 50% shortage of workers to fill vacancies in the employment structure. Therefore, a solution is needed to overcome this problem. To

overcome this, some efforts are needed to develop basic skills, soft skills (collaboration, communication, creativity, problem solving), and prerequisite values (Firman, 2018).

According to Firman (2018) the 2013 curriculum launched by the Ministry of Education and Culture will not be able to overcome the problem of the quality and quantity of Indonesian human resources with global competitiveness, if there is no systematical preparation for them to develop the knowledge, skills and attitudes required by the 21st Century work field, as manifested in STEM Education. The STEM approach can be a solution to create the next generation of the nation that is able to compete in the global arena. Therefore, STEM Education needs to be a frame of reference for the education process in Indonesia future.

As stated in the Basic Framework and Structure of the 2013 Curriculum for Middle School/Madrasah Tsanawiyah (Kemdikbud, 2013), the 2013 curriculum aims to prepare Indonesian people to have the ability to live as faithful, productive, creative, innovative, and affective individuals and citizens and able to contribute to the life of society, nation, state and world civilization. In the document also stated that one of the new mindsets used as a basis for the development of the 2013 Curriculum is change the outline of learning single knowledge (monodiscipline) into multiple scientific learning (multidiscipline). The formulation of goals and mindset in developing the proposed 2013 curriculum suggests that the 2013 curriculum provides space for the development and implementation of STEM education in the context of implementing the 2013 curriculum, which prioritizes the integration of S, T, E and M in multi- and trans-disciplinary and critical thinking, creativity, innovation, and problem-solving ability development (Firman, 2018). STEM education not only strengthening educational practice in STEM separately, but also developing an educational approach that integrates science, technology, engineering, and mathematics, by focusing the educational process on solving problems in daily life and professional life (National STEM Education Center, 2014). In the context of primary and secondary education, STEM Education aims to cultivate students who are STEM literate (Bybee, 2013) who have:

- (1) knowledge, attitudes, and skills to identify problems in their life situations, explain natural phenomena, design, and draw conclusions based on evidence regarding issues related to STEM;
- (2) understanding the characteristics of STEM discipline features as forms of knowledge, inquiry, and design initiated by humans;
- (3) awareness of how STEM disciplines shape the material, intellectual and cultural environment,
- (4) willing to be involved in the study of issues related to STEM (e.g., energy efficiency, environmental quality, limited natural resources) as a constructive, caring and reflective citizen by using scientific, technological, engineering and mathematical ideas.

STEM education provides an opportunity for teachers to demonstrate to students that concepts, principles, and techniques from science, technology, engineering, and mathematics are used in an integrated manner in the development of products, processes, and systems used in their daily lives (Firman, 2018, Masita et.al., 2021; Mordeno et.al., 2019). Therefore, Reeve (2013) adopted the definition of STEM education as an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in real contexts that connect between schools, the world of work, and the global world, thus developing literacy STEM enables students to compete in the new knowledge-based economic era.

One of the complicated problems being faced by the Indonesian people is the haze caused by the burning of forests. This problem occurs almost every year. This year the

smog not only covered number of provinces in Indonesia, but the impact was also felt by neighboring countries such as Malaysia, Singapore, Philippines and Thailand. Various adverse effects for humans and other living creatures caused by the smog. Impacts on humans include the emergence of respiratory disorders such as acute respiratory infections (ARI), pneumonia, and asthma. In addition, the smog also causes skin allergies and itching and eyelid disorders (conjunctivitis). Furthermore, the smog can also disrupt the digestive system if the dust gets into drinking water. Based on data from the National Disaster Management Agency's National Information and Public Relations Center, the number of sufferers of acute respiratory infections (ISPA) due to haze from forest and land fires as of September 2019 reached 919,516 people. As a science teacher, we should encourage young people to be more sensitive to problems that greatly threaten the survival of millions of these organisms. Therefore, literacy is needed for young people related to these problems, including in terms of reducing the impact of the haze on humans.

Based on that trending social current issue, the main purpose of this context based STEM Education Learning activity is to promote student think profoundly in probing the current social issues (reduce the effect of smog using air purifier). There are several considerations of coming up with the product such as its costs and effectiveness. Each of these will be addressed by providing appropriate activities to scaffold the attainment of its objectives and goals.

2. Developing the Smog Problem STEM education learning activities

This STEM Education Learning Activity will generate students to practice integrated knowledge among chemistry, biology, mathematics, art, and economics in order to design their products of air purifier. Chemistry concept may include colloid, mixture separation, and acid-base reaction. Biology concept may include human respiratory system and photosynthesis. Mathematics may include the measurement skills. Arts may include creative packaging of their air purifier. In addition, economics include profitability and low cost.

The lesson plan of this STEM Education learning activity was developed on concept of Context-based STEM education learning approach which the STEM education learning activities should provide not only the ways of investigation and solving problem but also a real-world problem solving. Regarding on Sutaphan and Yuenyong (2019), the context-based STEM education learning approach consist of 7 stages included (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage. The lesson plan could be provided as the table 1.

Table 1: Lesson Plan on Smog Problem in Indonesia adapting the Context-based STEM education learning approach

No.	Stage	• Activity
1	Identification of social issues	<ul style="list-style-type: none"> Teacher provides a video about the news of smog problem. Teacher asks students to identify the current social issues in the video. Students discuss trending problem about smog. Teacher asks students how to cope this problem. One of the ways to deal with the problem is using air purifier Teacher raises issue by question “what kind of air purifier that can be used effectively and bought cheaply/affordable by common people?”

No.	Stage	Activity
2	Identification of potential solutions	<ul style="list-style-type: none"> Students work in group to design a specific form of air purifier that is different each other. Each group identifies the possibility to develop their own design on the five capitals including physical, financial, social/technology, human, and natural capitals. For instance, students may come up with some ideas of capitals as following: Physical: The shape of the air purifier Financial: using low-cost/affordable material, Social/technology: choosing the right method that suitable for the air purifier making Human: The safety of air purifier Natural: The impact of developing this design/product toward the ecosystem and environment
3	Need for knowledge	<ul style="list-style-type: none"> Method: PjBL (Project Based Learning) To create a well-founded product, students need to gather related information. Teacher asks students to collect any information from various learning resources on what kind of gases which is existed in smog, how to reduce the dangerous gas in smog. Teacher asks students to gather information such by asking some people (teacher, school administrator, seller in school canteen, etc) about the range of air purifier's price that included into affordable categories. Based on the information gathered, the students have many considerations to build their idea of air purifier.
4	Decision making	<ul style="list-style-type: none"> Each group determine their own design of air purifier. Each group presents their own design of air purifier and defense it in classroom.
5	Development of prototype or product	<ul style="list-style-type: none"> Students in each group develop their own prototype of air purifier. Students create their own prototype at home, and bring the product to school on the next meeting. Students have to take a documentation in the form of photo or video for each step of their experiment.
6	Test and evaluate the solution	<ul style="list-style-type: none"> Students in each group tests their own prototype of air purifier Students collect data whether the air purifier works or not. In this data collection, students measure the composition of PM10 before and after the device is applied. Students revise the prototype based on the collected data
7	Socialization and completion	<ul style="list-style-type: none"> Students present the result of their mini project in classroom discussion. Students share the result of their mini project in social media, for instance instagram, facebook, youtube, etc.

This lesson is designed for 11th graders who are taking up Natural Science Interest. Each class will be divided into some groups and each group will be tasking themselves in the development of the product/prototype for the solution.

Stage 1. Identification of Social Issue

In this stage, the teacher provides a video about the news of smog in some provinces of Indonesia. Furthermore, the teacher asks students to identify the current social issues in the video.

The Problem

Smog from forest fire is an annual nuisance in Indonesia. This year the smog not only covered a number of provinces in Indonesia, but the impact was also felt by neighboring countries such as Malaysia, Singapore, Philippines and Thailand. Various adverse effects for humans and other living creatures caused by the smog. Impacts on humans include the emergence of respiratory disorders such as acute respiratory infections (ARI), pneumonia, and asthma. In addition, the smog also causes skin allergies and itching and eyelid disorders (conjunctivitis). Furthermore, the smog can also disrupt the digestive system if the dust gets into drinking water. Based on data from the National Disaster Management Agency's National Information and Public Relations Center, the number of sufferers of acute respiratory infections (ISPA) due to haze from forest and land fires as of September 2019 reached 919,516 people.



Figure 1. Indonesian forest fires burn causing toxic haze across south east asia
(Source :<https://www.theguardian.com/world/gallery/2019/sep/24/indonesian-forest-fires-burn-causing-toxic-haze-across-south-east-asia-in-pictures>)

Upon identifying the social issue, questions such as “How to cope this problem, especially to reduce the effect of smog in human body?” will be asked. It may lead students to think some possible solutions. After the students have some possible solutions, teacher may lead that one of the ways to deal with the problem is using air purifier. Furthermore, teacher emerge issue by question “what kind of air purifier that can be used effectively and bought cheaply or affordable by common people?”

Stage 2. Identification of Potential Solution

In the second stage, the teacher facilitates the class discussion about thinking of potential solutions to make air purifier that effective and affordable for reducing the effect of smog in human body. Each group identifies the possibility to develop their own design consider on five capitals including physical, financial, social/technology, human, and natural capitals. For instance, students may come up with some ideas of capitals as following:

Physical: The shape of the air purifier, for example simple (not too many materials)

Financial: using low-cost/affordable material,

Social/technology: choosing the right method that appropriate for the air purifier making

Human: The safety of air purifier. It means the air purifier safe to use, it is not dangerous for human body.

Natural: The impact of developing this design/product toward the ecosystem and environment. It means that the using of air purifier is not dangerous to the ecosystem and environment.

Stage 3. Need for Knowledge

In the third stage, teacher facilitates students to gather any information from various learning resources on what kind of gases which is existed in smog, how to reduce the dangerous gas in smog. This information related with some topics in chemistry, namely colloid, mixture separation, and acid-base reaction. Smog is aerosol, one kind of colloids. Smog contains small particles of solid dispersed in a gas. This initial information is needed to investigate the further information of smog. Therefore, students may need the principles of mixture separation or acid-base reaction when they create air purifier. In addition, students may also need photosynthesis knowledge because some of air purifiers create by using plant as a air filter. Besides, students also have to collect information about the range of air purifier's price that included into affordable categories. Students may ask to some people in their school such as teacher, administrator, seller in canteen or school shop, etc.

Stage 4. Decision-making

In the fourth stage, each group decides their own design of air purifier. After that, they present their own design of air purifier and defense it in classroom.

Stage 5. Development of the Prototype or Product

In the fifth stage, each group develop their own prototype of air purifier. Due to the limitation of time, they are impossible to finish their project in a meeting. Hence, the students create their own prototype at home and bring the product to school on the next meeting. Because they create the prototype at home, they have to take a documentation in the form of photo or video for each step of their experiment. Students may create some prototypes as following some examples below:

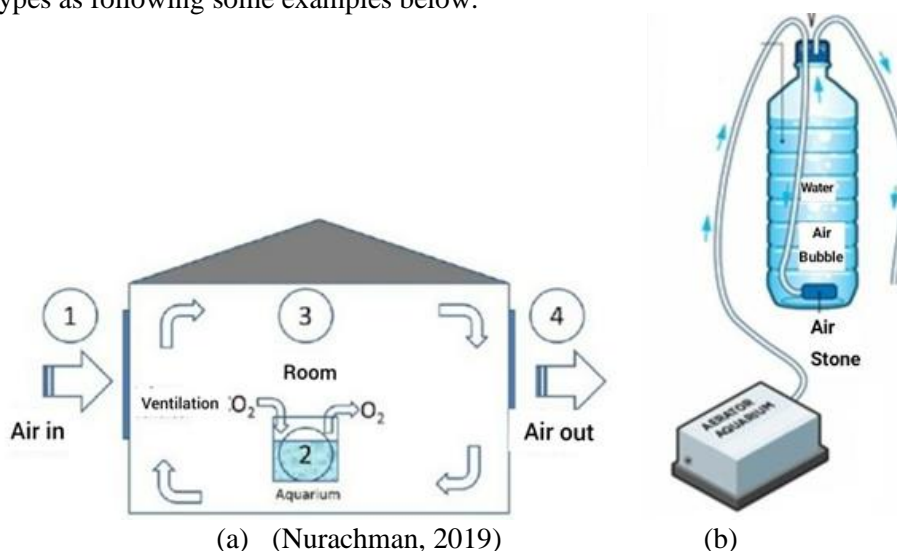


Figure 2. Some examples of air purifier prototype
 (Source: (a) <https://www.itb.ac.id/news/read/4942/home/zeily-nurachman-atasi-dampak-kabut-asap-dengan-alat-sederhana>
 (b) <https://twitter.com/kompasmuda>)

Stage 6. Test and Evaluation of the Solution

In the sixth stage, each group has to test their own prototype of air purifier. They will collect data whether the air purifier works or not. The students will measure the composition of PM10 before and after the device is applied. If the number of PM10 decrease, the prototype works well. However, if the number of PM10 constant or even increase, the prototype does not work well. Furthermore, students must revise the prototype based on the collected data. Besides, students also must evaluate whether the cost to create the air purifier affordable or not. Students may check by checklist of the price range that they gather in the previous stage.

Stage 7. Socialization and Completion Decision Stage

In the last stage, students must present the result of their mini research in classroom. Furthermore, students also must share the result of their mini research in social media, for instance Instagram, Facebook, YouTube, etc.

3. Conclusion

This paper shared the ideas of developing STEM learning activities about making air purifier as one of solutions to deal with smog problem in Indonesia regarding on Sutaphan and Yuenyong (2019) context based STEM education learning approach. The 7 stages of Sutaphan and Yuenyong (2019) context-based STEM education teaching approach could guide ideas of developing learning activities from social issues to develop some products. This STEM Education Learning Activity will allow students using applying scientific and other knowledge for designing the solutions, and provided the context of instruction requires solving a real-world problem or task through teamwork. As students' products of air purifier, students will have opportunity to apply their scientific and other knowledge for problem solving in context of engineering, technology, or entrepreneurship as well (Masita et.al., 2021; Sutaphan and Yuenyong, 2019).

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