Students’ statistical literacy through lab school car model in STEM activity

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Abstract. Indonesia’s education reformation had been focused on the mastering of 21st-century skills to increase global competitiveness and one of them is application of Science, Technology, Engineering, and Mathematics (STEM) education. Nowadays, many studies claimed that the implementation of STEM has a positive impact on the development of these skills, such as statistical literacy. However, the students’ statistical literacy in Indonesia still unsatisfied. Thus, this research was aimed at describing the implementation result of STEM activity by using the lab school car model for understanding the concept of data representation and interpretation namely statistical literacy. Students utilized used bottles to design the fastest and the most stable car. They experimented by operating their car then measured the time taken and the distance. After collecting the data, students displayed into statistical information, interpreted, and concluded. Students utilized technology for measuring and doing calculation as well as applying the concept of velocity, friction, and Newton’s laws to get the best design. This qualitative research conducted in one of Junior High School in Bali and also in Yogyakarta. It involved 51 students from both schools in the academic year 2019/2020. The data was collected by observation, documentation, in-depth interview, and practical test. The result indicates that the implementation of STEM leaning by using lab school car model can improve the students’ conceptual understanding of data representation and interpretation. In addition, it also improves the students’ creativity, motivation, problems solving ability, and communicate their understanding better.

1. Introduction
Science, technology, engineering, and mathematics (STEM) education defines as a method of teaching and learning that integrates four disciplines namely science, technology, engineering, and technology [1–4]. STEM education aims to integrate these disciplines for developing a useful product or system to solve real-world problems [4,5]. It implies that STEM education emphasizes on hand-on activity [6], innovation, creativity, and higher order thinking skill [3,7].

One characteristic of STEM education is engineering design process (EDP) [5,8]. Engineering design process is a methodological step for creating something real with a particular function to solve a problem [9]. Hafiz & Ayop [8] defines EDP is a pedagogical strategy that requires students to follow a set of steps to create the most effective solution that is iteratively tested and justified by mathematical and scientific concept. Berland et al. [10] stated that the characteristics of EDP including (1) the design process begins with problem definition; (2) design problems have many possible solutions and engineers must find systematic approaches to choosing between these; (3) design requires modeling and analysis; and (4) the
design process is iterative. In this current research, the EDP’s syntax as follows; 1) identify the problem, 2) research and brainstorming, 3) design or construct of a prototype, 4) test or evaluate 5) improve, 6) present the solution [5,9].

Various researches also were conducted to examine the effectiveness of the application of STEM education. Breiner et al. [2] said that STEM education can prepare students at all levels with the skill necessary to compete in our rapidly advancing technological society. Next, STEM education gives positive effects on classroom activities, scientific creativity, and motivation beliefs of the students [11]. learning outcomes [12], analytical thinking, decision-making, creative thinking, entrepreneurship, communication, and teamwork [13]. Siregar et al. [14] conclude that the STEM learning has significant effect to enhance the students’ achievement, attitude, interest, communication skills and problem-solving. In addition, Yildirim & Sidekli [15] said that STEM education have a positive effect to enhance individuals’ mathematical literacy. The role of STEM education is very important for preparing future generations in a highly competitive global economy. At present, STEM education has become one of the important issues in education. Thus, many countries have integrated STEM into their educational curriculum.

Following the explanation above researcher interests in conducting a learning that aimed at applying STEM education by using the lab school car model for understanding the concept of data representation and interpretation namely statistical literacy. It was caused by the lack of students’ difficulties in understanding the basic concepts of statistics and its application for solving real world problem that related with data. The lack of students’ statistical literacy impacts to the students’ mathematical literacy because both of them were closely related. This was evidenced by the result of PISA in 2018. It showed that the average of mathematics score of Indonesian students is 379 and it still below the OECD average of 489 [16]. In addition, for the students participating in this study, their basic statistics achievement during the past year has not met the curriculum requirement specifically to achieve 70 for the minimum score of mastery criteria [17].

Based on the aforementioned fact, the researcher considers it important to investigate the application of STEM learning by using lab school car model for enhancing the students’ statistical literacy. Thus, this article aims to describe the application of STEM learning by using lab school car model in the context of junior high school mathematics classroom in Indonesia and how it affects the students’ statistical literacy.

2. Method
This research is a case study to explore the experience of junior high school students in the application of STEM learning [18,19]. The overarching purpose was to understand the students’ activities in the experiment of lab school car model in STEM setting for learning statistics especially in collecting, representing, and interpreting data. Each participant constitutes a unit of analysis in the case study [18,20].

This research conducted in two places namely one junior high school in Bali that involved 20 students and one junior high school in Yogyakarta that involved 21 students in the first semester of the academic year 2019/2020. It was done in two places because researcher joined the Southeast Asia Mathematics Teaching and Learning Model 2019 that organized by SEAMEO QITEP in Mathematics. After nominating to be 3 best participants, the committee gave opportunity to the researcher for applying the learning model at Yogyakarta on November 14th, 2019.

The data of this research was collected by documentation, interview, and notes of the important or interesting findings [21]. The validity instruments were tested using source triangulation. Then, the data was analyzed through three phases namely data reduction, data display, and conclusion drawing verification [22].
3. Result and Discussion
At the beginning, researcher designed the lesson plan and students’ activity as well as analysed the elements of Science, Technology, Engineering, and Mathematics. The following table 1 is the analyses of the application of STEM.

| Science       | Applying the concept of speed, friction, and newton's laws that work on cars.  
|               | Reusing the waste of plastic and environmental pollution. |
| Technology    | Using calculator for doing computation.  
|               | Using technology for collecting data |
| Engineering   | Designing and operating the car  
|               | Making improvements and communicating the results of the project. |
| Mathematics   | Collecting data of the time taken and distance to find average speed then representing them into a table.  
|               | Analysing the relationship between time take, speed, and distance.  
|               | Presenting data into a graph and make the interpretation. |

The elements of STEM also displayed in the students’ activity which is integrating with engineering design process. Students learned about how to get the average speed of a vehicle from the data of distance and time taken. They also were expected to be able to know what the others factor that influence the car’s movement. The product was design by using recycle materials and it also gave opportunity to students for utilizing plastics waste which is able to polluting the environment.

At the beginning of the lesson, teacher gave a contextual problem related to the air pollution and environmental problem that caused by plastic waste. The problem stimulated students to utilize plastic waste for designing a car. One student told to others about his analyses about the impact of pollution on the earth and the best solution to solve it. Besides, there was a student have an idea to create a non-polluted car. This situation can exercise the students to think creatively and critically. After they were agreed to create a car, teacher asked students what is an ideal car? The answer of this questions to the constraint and the success criteria of the design. This is the first step in the EDP process, namely asking and identifying problems [5]. The question was asked by the teacher to direct students’ minds to be able to design a car like a technician. In this section, students expect to be able to identify the necessary elements that must be present in a model by imagining car models around it. This step is very crucial that will not be complete without thorough and thorough consideration or thought. Identifying the problem includes looking carefully at what is needed and seeing the constraints and rules that should be followed by students.

Students have different opinion but in the end of the discussion we conclude that an ideal car is should be fast and stable. To stimulate students, the teacher gives an example of a car design then they are given instructions to make a new one with the challenge that they must design the fastest and the stable car. Then, they discuss with their group how to design it and imagine the model [5]. Students discuss problem-solving to the questions posed by the teacher. Creativity plays a crucial role in this step. The teacher expects to be able to foster students' courage to observe every available material and write down the urgency of the materials used in problem-solving. It is also in line [6] that STEM education emphasizes on hand-on activity, innovation, creativity, and higher order thinking skill [3,7].

Students make a plan by drawing the design of the car that they will create. After drawing the design students create the fastest and stable car using the available material. Student will try to operate the car and measure the time taken and distance. And then, tabulate the data into a table, after that representing it in the line graph. Students have to make a reflection by looking again at their graph and describe about the movement of the car. Lastly, students must find at least one thing that has to improve in the next design. Students have to repeat the design in three times for getting the best car. If the stage is completed,
students can continue to describe “is the car always moving at the same speed? Why? Finally, teacher guide students to make a conclusion how to create the ideal car in terms of the fastest and stable.

Various designs were made by students who resemble those exemplified by the teacher. The student’s design was shown one of by figure 1 bellow.

![Figure 1. First design of the balloon car.](image1)

The figure 1 shows that students put the balloon at the top of the bottle, but if the position was not appropriate, the car not running well. The wheels also had to parallel each other in order to make it run stable. But, after the first design are tried by students, there were some elements had to be improved. One student has a different idea for making the car faster. Her idea and new design shown at the figure 2.

![Figure 2. Student’s improvement of the first design.](image2)

The final design, students made bottles become flat to reduce the friction force against the air. There are many interesting findings were recorded by researchers while students designed the car and discussed the problems that presented at the worksheet. The following is a brief segment that illustrates a common response in group 3:

S1 : After we designed and tried the first and second models the results were not satisfactory yet. Then, for the third car, I press this bottle so that it turns flat. In my mind, the air does not enter the bottle. When the surface of the bottle is flat, it will minimize the friction force with the air. This will cause our car to go faster.

T : How about the position of the wheels?

S2 : Yes, we place it carefully so that the position does not be oblique. It makes our car go fast and stable.

T : How to represent your data?

S3 : We use a line graph to represent our data. We use it because we want to observe a rising or falling trend in a set of data over a period of time. From this graph, we know the fastest speed at the middle period because of the biggest air pressure.
Students tried their improvement.

After getting the final design students tried their car and recorded the movement by their smartphone. Students collected the data of time taken and distance of the car. The last, students represented the data into statistical information and making the interpretations.

The participating student responses to the question "What do you think about STEM?" are presented below:

“I was motivated by the activities. I was directly involved in the observation, implementation process and did new things (S3).”

“I was more attracted, the products we produced in collaboration with friends were very creative (S19).”

“I have learned these topics so easily in an entertaining manner. (S10).”

From the students’ perceptions researcher can conclude that STEM learning give positive atmosphere for mathematics learning.

4. Conclusion

Based on the results and discussion above, it can be concluded that the experiment to create and use Lab School Car Model can increase the students’ enthusiasm and motivation, students’ creativity and critical thinking, give a good learning atmosphere, and improve the students’ learning achievement.

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