The Need Analysis in the Development of Students’ Virtual STEM Project for Science Education

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Abstract. The 21st century learning outcomes emphasize high-order thinking skills and information technology literacy. Using these skills, students can solve problems and think innovatively. Even though it has not been implemented optimally, STEM is a learning approach that is considered to be able to build high-level thinking skills of students. This study is an analysis phase in the development of virtual STEM for learning science. There were 52 respondents who participated in this survey. They are science teacher in Riau and Kepulauan Riau province. A questionnaire was used to identify the extent of respondents’ understanding about STEM and STEM implementation. The questionnaire also identified science teachers’ view of virtual STEM and the availability of computer facilities that support virtual STEM both at school and at students’ homes. In this study, we found that some science teachers have already understood STEM but have not yet been implemented in their teaching. Especially for electrical circuit material, a virtual STEM project can be used as an alternative to overcome the problem of time constraints in running a project and is expected to improve the ability to think creatively.

1. Introduction
The results of a survey conducted by PISA in 2018, showed that, the level of scientific literacy of Indonesian students was ranked 70th out of 78 countries, with a score of 396 [1]. This shows that the learning process of science is still problematic. The results of Murnawianto's study [2], show that the average thinking ability of our students is only at the low-order stage of thinking skills. Therefore, science learning that is oriented towards building high-level thinking skills must be a top priority for science educators and the government. Especially now, we are in the 21st century and the industrial revolution 4.0 era. In this era, education must be able to produce students who have strong character, competitive, critical thinking, and mastering in information technology.

In teaching science, one approach that is considered capable of increasing the ability to think critically and creatively to face the challenges of the 21st century is the STEM approach [3]. This STEM (science-technology-engineering-math) approach integrates science, technology, engineering and mathematics [4]. This integration is realized in the form of student’s projects of STEM. The STEM project aims to give students the confidence that what they are learning in science and mathematics can be applied to produce useful products. With STEM, learning science becomes beneficial for students. STEM involves learning across knowledge, skills and values in all STEM fields. This integration makes STEM a new discipline in the context of connecting experiences gained at school with the reality of everyday life [5].
The STEM education approach requires basic knowledge and strong concept understanding to enable students to understand and apply STEM knowledge. Science educators should not just teach but are expected to guide students in connecting what they learn in school with the context of their daily lives. Therefore, the STEM approach is an alternative to connecting STEM subjects and providing context relevant to the learning process [5],[6]. STEM is one form of implementation of the constructivist approach, not mentioning the specific stages and knowledge gained, but at each stage is ultimately related to each other. STEM is called the "global literacy" skill. STEM is not a model, or teaching technique. STEM is an approach that is a continuation of constructivist learning [7]. Bozkurt's study [8] shows that, science teachers have a positive perception of the application of STEM in learning.

In accordance with the National Governor's Association Center, STEM is defined as follows. Science refers to scientific literacy, namely the ability to use scientific knowledge and processes to understand the world and to participate in making decisions to influence it. Technology refers to technological literacy, namely knowledge of how to use new technologies, understanding how new technologies are developed, and having the ability to analyze how technology influences individuals, communities, nations, and the world. Furthermore, engineering refers to how technology can be developed through an engineering or design process using project-based learning themes by means of integration of several subjects. Meanwhile, mathematics refers to mathematical literacy, namely the ability to analyze reasons, and communicate ideas effectively from how to behave, formulate, solve, and interpret solutions to mathematical problems in applying different situations.

The implementation of STEM in learning, especially science learning in Indonesia, is not yet encouraging. The results of study [9] show that the implementation of STEM in schools in Pekanbaru Indonesia is still very low. Therefore, the implementation of STEM approach must be more optimized. It needs to change the paradigm of thinking, from STEMs that are considered difficult into STEMs that are more flexible, so that they are easily implemented.

Project-based virtual lab applications are seen as an option in applying the STEM approach in learning science on certain topics. Furthermore, [10] asserted that virtual lab applications are the best solution that meets the needs of science education in situations where laboratory resources are not available. In addition, the virtual lab is seen to minimize the use of time in the process of science practice. Virtual lab technology provides several benefits for students and also teachers. Virtual STEMs are flexible and provide students with the variability of experimental projects that can be carried out by a greater number of students. Students can work independently. This method also provides easy configuration and resistance to damage [11].

In this initial phase of study of developing STEM virtual, the researcher need to obtain various information related to the need to build a virtual STEM project module. The research questions include:

a. How far does the science teacher understand about STEM?

b. How far is the implementation of STEM in science learning?

c. What is the view of science teacher about STEM virtual?

d. How far is the availability of supporting facilities for implementing virtual STEM?

2. Method

A survey of 52 respondents was conducted. Respondents are science teachers in Riau Province and Riau Islands Province. The instrument used in this study was a questionnaire that could identify the need for developing virtual STEM project. The instrument consist of 20 items that explored information about the need for STEM in learning, respondents' understanding of virtual STEM, availability of STEM support facilities, and the design of virtual STEM modules according to respondents. The instrument is distributed online using googleform. The research data were analyzed descriptively including percentages and pie and bar graphs.

3. Result and Discussion

Analysis of research data provides an overview of the state of science learning related to the application of STEM approaches. Data analysis also shows the factors that become obstacles in
applying the STEM approach. Besides that, also identified opportunities for the implementation of virtual STEM, and the respondents' suggestions for the developer of the virtual STEM project and learning module.

3.1. Understanding about STEM education
All respondents gave opinions about their understanding of the STEM approach in learning science. Respondents' opinions regarding the importance of STEM project-based learning and the effect of STEM on critical thinking skills and creative thinking skills are shown in Figure 1 and Figure 2.

Figure 1. The need for project-based learning in science education

Figure 1 shows that almost all respondents stated that project-based learning was indispensable in learning science. The reason respondents stated the importance of the project in learning science is that the STEM project can improve critical thinking skills and creative thinking skills for students as shown by Figure 2. Figure 2 shows that all respondents agreed that critical thinking skills and creative thinking skills can be built through learning that is STEM project oriented. With STEM education, students understand new information they learn, present it to their daily life or environment, and adapt [12].

3.2. Implementation of STEM education
The survey in this preliminary study also identified the extent of the implementation of STEM in learning science so far. Researchers focused on learning about electrical circuits. Analysis of the survey results is shown in Figure 3 and Figure 4.

Figure 3. Implementation of STEM in science learning

Figure 3 shows that the STEM approach is still unfamiliar strategy for students and science teacher in our country. Almost all respondents said they rarely use this method in their learning. In fact, 11%
of respondents have never tried this approach at all. Only a small proportion of respondents (4%) stated that they always applied the STEM approach in their science teaching.

This survey has also identified methods that are always used by teachers in teaching science. The survey analysis for this problem is shown in Figure 4. In order for the respondent's answers to be directed, the researcher brings the items of the questionnaire statement into the context of the electrical circuit topic. More than half of the respondents stated that teaching electric circuits using the lecture method is accompanied by discussions in answering questions. Meanwhile 21% of respondents use the inquiry approach with the experimental method. A small number of respondents claimed to use project-based learning in teaching electrical circuit topic.

3.3. Views on the need for virtual STEM

The use of computer technology in carrying out electrical circuit projects virtually is an alternative for science teaching. Besides that, students more quickly learn various computer applications compared to adult. For the design and testing of electrical circuits, various computer applications are available, Lifewire application is one example. The science teacher's view of the using virtual STEM project teaching electric circuits topic is shown in Figure 5 and Figure 6.

![Figure 5. Time constraints for analog projects of electrical circuit](image1)

![Figure 6. Analog projects tend to be fixated on the schema of electrical circuit in the task sheets](image2)

Figure 5 shows that almost all respondents agreed that the electrical circuit project undertaken by students in analog would require more time. Although the circuit scheme has been provided in the assignment sheet, the process of assembling and testing the electrical circuit takes longer. This is in line with the opinion of the majority of respondents, namely the analog electrical circuit project makes students too fixated on the circuit schematic in the student project assignment sheet, as shown in Figure 6. Students tend to want to complete their project without getting the opportunity to make variations of the circuit.

Figure 7 shows the science teacher's view of the advantages of virtual STEM. Nearly all respondents agreed that the virtual STEM approach to electrical circuit material gave students the freedom to make their own designs so that they became more creative. Students can build ideas that are different from the assignments. In addition, almost all respondents view that virtual STEM projects can be implemented more quickly and easily varied. Students can make the same electrical circuits as given assignments, but with different circuit models or students can make variations of the electrical circuits and test their functions quickly.
The above respondents’ predictions is in line with the findings of Aşiksoy & Islek [13], namely the use of virtual lab in science education can increase student achievement and their satisfaction. Virtual labs make the concept of science (physics) easier and faster to be applied and, it gives positively influence to the student attitudes. Besides that, Trúchly [11] states that virtual and augmented reality applications, multimedia applications, virtual labs, and real laboratories are new trends that can help students to engage in STEM fields, and help them to imagine and understand difficult and abstract problems.

3.4. Virtual STEM supporting facilities
Because of virtual STEM can be implemented in science teaching, especially in electrical circuit material, so, computer facility support is needed. Figure 8 shows the availability of computer facilities in schools. Meanwhile, Figure 9 shows the availability of computer facilities in students’ homes according to science teachers.

**Figure 7.** Respondent's view of the virtual STEM of electrical circuit project

The results of this survey show that virtual STEM can be implemented in teaching science in schools, because almost all schools already have computer facilities such as computer labs and laptops.
for learning. Even though, there are school computer labs with insufficient computers. For this disadvantage situation, science teachers can organize students to implement virtual STEM projects in small groups, so, it doesn’t need a lot of computers or laptops. Anyway, collaborative learning will foster students' social attitudes. According to Figure 9, the assignment of STEM virtual projects on electrical circuits for homework is not yet possible. This is due to the lack of computer facilities in student homes. Science projects for others science topic (beside electrical circuits that do not require computer facilities) can be carried out at home. Zulirfan's study [14] has found that students feel happy to carry out scientific activities at home and can enhance scientific skills and attitudes.

4. Conclusion
Science teachers' understanding of the STEM approach is sufficient. STEM is an important approach to improve critical and creative thinking skills. However, the STEM approach in general has not been implemented in schools optimally. Most of our science teaching is still oriented towards achieving content or transferring knowledge through lecture and practicum methods. Because the limited time is the main obstacle for STEM project implementation, the virtual STEM project, especially for electrical circuit material, is a form of solution. Virtual STEM is seen as able to overcome the problem of limited project implementation time. And, the most important thing is, the virtual STEM is seen to be able to build students' creativity in designing and testing their own electrical circuit projects.

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