Use of bungee jumping with stem approach to improve science process skills

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Abstract. The purpose of this study is to make bungee jumping as a teaching aid or learning medium by using the STEM approach to the material of straight-line equations. The method used in this study is the experimental method using one post-test group design. In this study, students create projects, then students are guided to make bungee jumping. The process of making this bungee jumping goes through several stages which include the planning stage, the implementation phase, the report writing stage, and the presentation stage. The results of the project were assessed as feasibility of science process skills. The assessment is carried out at each stage of the process of making bungee jumping, starting from the planning to the presentation stage using a special assessment rubric. Learning using the STEM approach is expected to be able to build and develop students so that they not only memorize concepts, but are also guided to be able to integrate science, technology, engineering, and mathematics so as to improve students' science process skills. The results show that making bungee jumping through the application of the STEM method can improve students' science process skills in both categories by 79.13%.

1. Introduction

The 21st century is a century of rapid technological development in various countries [1]. Science and technology are developing rapidly, students are required to master a variety of skills in order to compete globally [2, 3]. The development of science and technology demands an increase in the quality of education [4]. Education has a role in preparing human resources who are able to think independently, creatively and critically, because education is the basic capital for quality human development [5]. Education is a very important thing in human life. Along with the development of the era, especially in the 21st century, the demands of human life are increasingly high. Of course quality human resources are needed in order to compete with the challenges of the 21st century [6 – 8].

One of the 21st century skills needed is science process skills [9]. Important science process skills possessed by students in scientific learning activities to solve various science problems [10 - 11]. Science process skills are all abilities needed to acquire, develop, and apply scientific concepts, principles, laws and theories in the form of mental, physical, and social abilities [12]. Science process skills include observing, interpreting observations, classifying, communicating, predicting, formulating hypotheses, analyzing data, designing experiments or experiments, applying concepts or principles, asking questions, using tools, measuring and drawing conclusions [13 -14]. Process skills are formed only through repetitive processes [15]. Students cannot be skilled if there is no opportunity to carry out the process by themselves continuously [16]. Process skills need to be developed through
direct experiences as learning experiences [17]. Because through direct experience, someone can better appreciate the process or activity that is being carried out [18].

Based on the results of preliminary studies that we have done, it shows that what happens in the field of science learning is still relatively untouched in developing scientific process skills optimally. This is caused by several factors such as: low science background, lack of laboratory infrastructure, textbooks as the only guide in learning and school administration has not initiated contextual learning, only emphasizes mastery of concepts and learning activities that have not explored students' science process skills. The root of the problem of science process skills is low because the learning model applied is not yet optimal in training science process skills, so we need a learning model that is able to empower students' science process skills [19]. Science process skills need to be developed through direct experience involving the use of various materials and physical actions [20]. The development of science process skills is used to help students gain an understanding of material that is more long-term memory so that it is expected to be able to solve all forms of daily life problems, especially in the face of global competition [21]. Broadly speaking the factors that influence the low level of science process skills of students occur due to the lack of optimization of learning that involves the role of students [22]. Learning that takes place shows students are less skilled and actively participate in the learning process, students tend to be more silent and just pay attention to the material presented [23].

In this case the teacher needs to use a learning approach that can train students' science process skills and score students with global competitiveness, namely the STEM (Science, Technology, Engineering, and Mathematics) learning approach. STEM is an interdisciplinary approach by integrating four disciplines applied in a real world context [24, 25]. Based on the research, the results obtained by making creative products by integrating STEM knowledge are able to influence the level of student creativity, creatively influenced by STEM knowledge that can support student creativity by integrating knowledge, skills, and the ability to solve everyday problems [26, 27]. Learning with the STEM approach can give students a learning experience, active learning and contextually meaningful [28]. The STEM approach provides a positive influence on student learning [29]. Furthermore, the STEM approach can improve students' critical thinking skills in urban schools, specifically the ability to provide inductive reasons and draw conclusions [30 – 32]. The integration of STEM education in teaching and learning can be carried out at all levels of education, starting from elementary schools to universities, because aspects of STEM implementation such as intelligence, creativity, and design ability do not depend on age [33].

2. Method
The method used in this study is an experimental method by taking data one post-test design only which can be seen in Figure 1 below.

![Figure 1. Experiment method with one post-test design only.](image)

The experimental research method is a method used to look for the effect of a particular treatment on objects to be studied under controlled conditions [34]. Experimental method is a way of presenting lessons, where students conduct experiments by experiencing and proving themselves something learned, which aims to find out whether a method, procedure, system, process, tool, and material, as well as an effective and efficient model if applied somewhere [35]. In this experimental research there is treatment given to students. This is done to investigate whether there is a causal relationship and how much the causal relationship is by giving treatment to students. This study aims to determine the science process skills of students who develop in learning straight line equations with the STEM approach that is making projects in the form of bungee jumping designs.
In this activity students’ work in groups, then students make a simulation of bungee jumping activities and explore the relationship of the rope used with the falling distance that occurs. Broadly speaking, students are asked to carry out learning activities as shown in Figure 2 below.

![Figure 2. Learning activities.](image)

Based on Figure 2, students discuss in groups, then students are asked to design a bungee jumping design. After that students are asked to predict the relationship between the amount of rubber and the distance to fall with a certain height. Next students are asked to answer the challenge by determining the amount of rubber band needed as a rope so that the object remains safe when playing bungee jumping at a height of 395 cm.

Science process skills tests measured in this study include asking questions, hypothesizing, planning experiments, observing, interpreting and communicating. Science process skills tests conducted in the form of tests and non-test. The data described is the data from the observation sheet of the science process skills test and the learning achievement test in the form of a description of 11 questions. Observations were made of 30 students of class VIII. This research was conducted at one of State 7 High Junior School in the city of Serang, Banten. This research was conducted in the even semester of the 2018-2019 school year.

3. Result and Discussion

Science process skills are skills that are derived from training basic mental, physical, and social abilities as drivers of higher abilities [36]. The process skills described in teaching and learning activities pay attention to the development of knowledge of attitudes, values and skills [37]. The aspects of the science process skills examined in this study include asking questions, observing, hypothesizing, planning experiments, interpreting, and communicating.

The following is the elaboration of the results of research on the use of students’ science process skills tests on the subject of straight-line equations with the STEM approach that is making projects in the form of bungee jumping designs. The assessment used in this study, students use observation sheets used to monitor student skills through bungee jumping design activities. The scale used is 1-4 and then converted into a percentage value category. For more details, the results of the assessment of science process skills assessment can be seen in table 1.

| Aspects of science process skills | Value | Percentage | Categories |
|----------------------------------|-------|------------|------------|
| Asking                           | 3.17  | 79.25      | Well       |
| Hypothesis                       | 3.07  | 76.75      | Well       |
| Planning                         | 3.25  | 81.25      | Very good  |
| Observing                        | 3.68  | 92         | Very good  |
| Interpreting                     | 2.81  | 70.25      | Well       |
| Communicating                    | 3.01  | 75.25      | Well       |
| Average                          | 3.17  | 79.13      | Well       |
Table 1 shows that the average score of “asking question” aspect is 3.17 of 79.25%, hence, the students’ skill categorized as well. This is on the grounds that asking question is a simple thing for pupils. Seen while presenting problem on student worksheets and pupils were approached to give clarifications, they responded genuinely well. Additionally, many students pose inquiries without any hesitation on the experiment. However, some students still in doubt and afraid to ask question. Posing questions is a key aptitude that students must have before learning a more complicated problem. Science process skills in this part of posing question utilize the accompanying pointers: approach to request a clarification, and get some information about the investigations led.

At the hypothesize aspect, the mean score retrieved by the student is 3.07 or 76.75%, and hence, categorized as well. The capacity to generate hypotheses is one of the most essential abilities in scientific work. Hypotheses is a sensible gauge to clarify a specific occasion or perception. Students at this stage would already be able to anticipate the following occasion or is known as a creating hypothesis. The majority of students were right and the outcomes specified well.

The average score of students in “planning an experiment” aspect is 3.25 or 81.25% and categorized as very good. Prior to experiment, students must make plans, for example determining the object of observation, the technique of measuring and collecting data, the materials and tools, and data analysis. At this stage, students were highly excited to plan an experiment. Hence, the results were classified as very good. They were glad to have the option to collaborate straightforwardly with the ideas or material being considered.

In the observing aspect, the average score retrieved by student is 3.68 and the percentage of 92%, therefore the student skill is categorized as very good. Making an observation is one of the basic scientific skills. Observing is different with seeing. In observing, students must activate all the senses like seeing, hearing, feeling, tasting and kissing. The indicators of observation in science process skills are: activating all the senses as many as possible, and collecting / apply relevant facts. This aspect earns the highest score by students. This was visible during the experiment, where students were highly enjoy the process of making observations.

Interpretation comes as the fifth aspect of science process, where the students obtain an average score of 2.81 with a percentage of 70.25% and categorized as well student skills aspects. Similar to the aspect of observing, the interpreting aspect also has some indicators namely. The indicators are connecting the data from observations, extracting the patterns based of the observation, and making conclusion. At this stage, students are good at interpreting an experiment into the thought process.

The sixth aspect of the science process is communicating. The average score of students' skills in communication is 3.01 or said that the percentage of 75.25%. Therefore, the category is considered as well. Communicating should be visible through writing, drawing, (graphics or charts), reading and speaking (discussion and presentation). depicting exact information on the consequences of trials or perceptions with charts or tables or graphs, talking about the aftereffects of analyses and contrasting information and different gatherings and aggregating and submitting reports deliberately. Besides, the information from watching science process aptitudes can likewise be found in Figure 3.
Based on Figure 3 the results of the research on the observation sheet, from all aspects of students’ science process skills there are the highest and lowest aspects. The observing aspect is the highest aspect with an average percentage value of 92%. This is because in this aspect students are invited or interact directly with real objects or events. So students feel happy when observing activities. Interpreting aspect is the lowest aspect with an average percentage value of 70.25%. This lacks the students’ ability to interpret an experiment. From all aspects of science process skills, the average value of students' skills is 3.17 so that a percentage of 79.13% is obtained or categorized as good student skills. This shows that learning using STEM with experimental methods or making projects by designing bungee jumping can improve students' science process skills.

Learning using the STEM approach is expected to be able to build and develop students so that they not only memorize concepts, but are also guided to be able to integrate science, technology, engineering, and mathematics so as to improve students’ science process skills. These science process skills are important to help improve human resources in the future. This is in line with the results of research that STEM can help bring out the skills and abilities of students in understanding competition in the real world that requires application of these four interconnected fields of science [38]. This STEM learning approach is able to build students’ thinking power that is needed to increase students' ability to solve problems through collecting and analysing various problems that arise, so as to help students prepare their skills in the world of work [39].

Furthermore, these results are also in line with the formation of STEM, namely developing abilities in students by combining several fields of science [40]. Students in learning are more active in developing the skills they have, so that they not only understand the material mathematically, but by using other learning components. It can be said that project-based STEM learning is one of the right methods in measuring improvement in science process skills. This is consistent with research that learning processes that use project methods produce better process skills than conventional classes [41]. Learning with projects is constructivist, where students build their own understanding with the help of groups [42]. In addition to being able to develop students' intelligence potential, project learning is able to form collaboration between students well and be able to understand the concepts of science in greater depth because students create works directly by applying the concepts that are in the work [43]. Furthermore, that learning by making projects able to develop students' thinking abilities, develop student creativity, encourage students to collaborate in a team [44]. The results of other studies also showed that students' scientific process skills could be formed through direct experimental methods, namely making briquettes [45]. Project methods are an alternative in developing science process skills. Project-based learning is able to provide the best value in science process skills.
Effective project-based learning is used to prepare future teachers to design and manage learning environments that can develop science process skills.

4. Conclusion
Based on the results and discussion above, the data concluded that the STEM approach using the experimental method that is the design of bungee jumping is very appropriate to improve science process skills. The results show that the science process skills are in the good category, which is 79.13%.

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6. Acknowledgments
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