



## Effectiveness of Environmental Change Learning Tools Based on STEM-PjBL Towards 4C Skills of Students

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### Abstract

Skills that must be possessed in the 21st century include critical thinking and problem solving, creativity and innovative skills, collaboration and communication skills (4C) in order to be able to survive and compete globally. This study aims to analyze the effectiveness of environmental change learning tools based on STEM-PjBL including syllabus, lesson plans, teaching materials, student worksheets and evaluation tools on students' 4C skills. The learning model used in this study is Project Based Learning (PjBL). The study was conducted at SMA Negeri 4 Medan and SMA Negeri 16 Medan class X. Samples were taken using a purposive sampling method consisting of 4 classes with a total of 126 students. This research uses quantitative research methods with one group pretest-posttest design. The results showed the implementation of learning activities based on the activities of teachers obtained a score of 0.915 with a very good category. Furthermore, critical thinking and problem solving skills get an average score of N-Gain 0.587 with the medium category, creativity and innovative skills get an average score of 0.809, collaboration skills score 0.816 and communication skills score 0.825 with all categories very good. These results indicate that environmental change learning tools based on STEM-PjBL is effective against students' 4C skills.

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## INTRODUCTION

The challenges of the 21st century require one to have some skills that must be mastered, so students need to be prepared to master these skills. This is intended so that students are able to survive in global competition. The Partnership 21 (2011) mentions the skills that must be possessed include critical thinking and problem solving skills, creativity and innovative, collaboration and communication (4C). By having 4C skills, students are expected to be able to think critically to solve problems that occur around students through creativity and innovation. By collaborating, work becomes more effective and efficient to do and with effective communication there is no misunderstanding with other people.

Indonesia is the country ranked second as the largest producer of waste to the sea (Jambeck et al., 2015). According to Environmental Protection Agency (EPA) (2017), Medan City is the number 4 polluted city in the world after Ludhiana (India), Lanzhou (China), and Mexicali (Mexico). The condition of Medan city environment like this is due to the behavior of Medan residents who do not care about the environment. With 4C skills in learning activities, students are expected to be able to solve environmental problems around students, especially in the city of Medan creatively and innovatively as well as effectively and efficiently. This underlies the importance of 4C skills in learning activities. However, learning that links environmental problems by emphasizing the values of 4C skills in Medan is still rarely done and is still limited.

STEM is an approach to learning by combining aspects of Science, Technology, Engineering and Mathematics in a learning activity. STEM was first introduced in America. Learning with the STEM approach has been proven to be able to improve 21st century students' skills. Some studies on STEM learning tools include Shahali et al. (2016) stated that junior high school students in Malaysia showed an increase in interest in system by 69.9% and interest in careers in STEM by 82%. According to Tunkham et al. (2016) STEM learning approach is able to improve academic achievement and 21st century innovation skills of students. Tunkham et

al. (2016) also states that the STEM approach is able to improve student information media literacy and technology literacy very well, as well as improve students' life and career skills at an very good level. Meanwhile, Suwarma et al. (2015) states that STEM learning is able to increase motivation and provide experience in the engineering process and be able to improve student achievement in school final exams.

Project Based Learning (PjBL) is a learning model that is built based on learning activities and real assignments (projects) that pose challenges for students to solve. These activities generally reflect the type of learning and work done in daily life outside the classroom. The PjBL learning model is an innovative learning that teaches many strategies for student success in the 21st century (Bell, 2010). Milla et al. (2019) states that the PjBL learning model is able to improve students' science process skills as well as students' creative skills. This is one of the strategies for student success in the 21st century. Meanwhile, Moylan (2008) states that learning using the PjBL model is very important. This can close the gap between knowledge and the skills students have to succeed in the 21st century.

One effort to improve 4C skills is to use STEM learning tools in combination with the PBL learning model. Becker & Kyungsuk (2011) state that STEM subject linkages in learning have a significant positive effect on student learning outcomes, so STEM can be used as an alternative to science learning that can build generations that are able to face a challenging world in the 21st century. Furi et al. (2018) states that STEM integrated in the PjBL learning model shows an increase in student learning outcomes (cognitive and psychomotor aspects) and student creativity in problem solving. Meanwhile, Afriana et al. (2016) stated that learning with the STEM-PjBL approach showed an increase in the scientific literacy results of male and female students.

In this study, the STEM approach with the PjBL learning model is integrated into the environmental change learning tool which includes syllabus, lesson plans, teaching materials, student worksheets and evaluation tools. The purpose of this study was to analyze the effectiveness of STEM-based learning tools for environmental change using the PjBL learning

model for students' 4C skills. The hope, by using this STEM learning tool is able to improve students' 4C skills so that students are able to face challenges in the 21st century.

## METHODS

The trial was conducted at SMA Negeri 4 Medan and SMA Negeri 16 Medan in class X IPA. Sampling research using purposive sampling consisting of 4 classes with a total sample of 126 students. The trial used a one group pretest-posttest design experimental model according to Sugiyono (2009). Learning activities carried out for 9 hours of study or for three times the meeting. The learning model used is Project Based Learning (PjBL).

Data on the implementation of learning activities obtained through observation based on the activities of teachers in using STEM-PjBL learning tools. Data on creativity and innovative skills, collaboration and communication skills were obtained by observing during the learning activities in the research. Indicators of creativity and innovative, collaboration and communication skills based on the Office of Superintendent of Public Instruction (2015). The effectiveness analysis of environmental change learning tools based on STEM-PjBL can be seen from the implementation of learning activities based on teacher activities and student learning outcomes which include creativity and innovative skills, collaboration and communication skills with the following formula.

$$value = \frac{earnings\ score}{maximum\ score}$$

Based on the value obtained, then the value is grouped into several categories. The score acquisition category can be seen in Table 1.

**Table 1.** Criteria for the Implementation of STEM-PjBL Learning, Creativity and Innovative, Collaboration and Communication Skills.

Total Score	Category
$0.80 \leq x < 1.00$	Very good
$0.60 \leq x < 0.80$	Good
$0.40 \leq x < 0.60$	Good enough
$0.20 \leq x < 0.40$	Not good enough
$0.00 \leq x < 0.20$	Not good

Critical thinking skills data obtained by providing pretest and posttest questions totaling 25 items in the form of multiple choice and 5 items in the form of description. Questions given in the form of questions with cognitive level C4-C6 or referred to as HOT questions. Data analysis using the N-Gain test with the following formula.

$$Gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

From the above calculation, then the Gain value is grouped by the acquisition score category. The score acquisition category can be seen in Table 2.

**Table 2.** N-Gain Score Criteria

Interval	Criteria
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Medium
$g \leq 0.3$	Low

## RESULTS AND DISCUSSION

The data in Table 3, below shows the results of learning activities using the environmental change learning tool based on STEM-PjBL.

**Table 3.** Results of Learning Activities

Aspects of assessment	Average score	Criteria
Implementation of STEM-PjBL learning	0.915	Very good
N-Gain <i>critical thinking and problem solving</i>	0.587	Medium
Creativity and innovative skill	0.809	Very good
Collaboration skills	0.816	Very good
Communication skill	0.825	Very good

In Table 3, the STEM-PjBL learning activity scoring score was obtained based on the teacher's activity of 0.915. These results indicate that the learning process carried out effectively and in accordance with the expected indicators. This is because the teacher has been able to carry out learning activities with the learning syntax of PjBL by integrating STEM aspects. In learning activities, the teacher plays a very important role. This is consistent with Theodora (2015) which states that teacher teaching skills affect student learning outcomes. This is evidenced by the very good student learning outcomes in research. This

teacher activity does not rule out the possibility that if the teacher continues to use the STEM device it will affect student learning outcomes. This is in accordance with Han et al. (2015) which states that teacher activities that consistently use the STEM approach with the PjBL learning model are able to reduce disparities in student achievement in schools.

Based on Table 3, critical thinking and problem solving skills gained an N-Gain score of 0.587. This means that there is an increase in the learning outcomes of critical thinking and problem solving using environmental change learning tools based on STEM-PjBL in the medium category. This is in accordance with the research of Furi et al. (2018) which shows an increase in learning outcomes of critical thinking skills with the STEM approach in the medium level category. Capraro & Craft (2017) states that the STEM approach that is integrated with the PjBL learning model combines accuracy that connects with real-world situations thereby increasing student involvement in the learning process and student academic outcomes.

The students' critical thinking and problem solving skills in this study were trained by providing description questions with a cognitive level that is Higher Order Thinking (C4-C6) at each end of the student worksheet. According to Ratnanigtyas & Wijayanti (2016), the description questions in the student worksheet are able to improve students' analytical skills, the ability to provide alternative answers and the ability to distinguish useful and useless information and the ability to evaluate. Furthermore, the evaluation questions used are multiple choice questions and the descriptions presented in the learning kit also have HOT criteria. According to Arifin (2017), HOT questions can be used to measure students' critical thinking abilities.

Creativity and innovation skills based on Table 3, get a score of 0.809 with a very good category. The results of this study are in line with Siswanto (2018) which states that learning developed using the PjBL approach influences students' creativity and innovative abilities. This is because in STEM learning which is integrated with the PjBL learning model students are invited to do meaningful learning in understanding a concept. Students are invited to explore through

project activities in this case students investigate the level of environmental pollution that occurs around students. In investigative activities, STEM aspects are integrated in PjBL learning activities covering aspects of Science in the form of science of environmental pollution, Engineering in the form of steps in carrying out projects / investigations, and Mathematic in the form of analysis of investigative data. According to Capraro & Slough (2013), project activities make students actively involved in learning so as to be able to foster critical thinking, creative, analytical, and improve students' higher-order thinking skills.

Furthermore, Ismayani (2016) states that STEM-PjBL based learning is able to increase student creativity. Student creativity can be developed through learning that develops imagination by giving students the opportunity to write and solve problems with diverse ideas. This is in accordance with STEM-PjBL learning tools. In this environmental change learning tool based on STEM-PjBL, students' creativity and initiatives are developed through the activities of students giving their ideas to provide solutions to solve environmental change problems by making products (technology). Products in environmental change are not limited, thus providing opportunities for students to be able to develop their varied imaginations.

Sahin & Top (2015) and Saenab et al. (2019) stated that STEM learning approaches can improve collaboration skills. This is consistent with the results of the study based on Table 3 which shows collaboration skills in the very good category. In collaboration activities, students contribute to the group. Students have been able to collaborate even though small conflicts were found during the discussion. Lee et al. (2015) states that finding conflicts in learning is very influential on problem solving skills / conflicts in groups so that they can improve students' collaboration and communication skills. Pratiwi et al. (2018) also emphasized that through collaborating in groups with PjBL learning it was able to improve student collaboration skills. Furthermore, during collaborative activities, students have been able to work together to achieve common goals even though a number of minor conflicts were found. Students have also been able to take responsibility by contributing

each individual in the group. This is in accordance with Hamidah & Palupi (2012) which states that learning with the PjBL model is able to increase the attitude of student responsibility. In addition, Fitri et al. (2018) states that learning that exercises collaborative learning activities is related to student test results.

The results of communication skills on STEM-PjBL tools showed an average result of 0.825 in the very good category. These results are in line with research by Muharromah et al. (2019), Nugroho et al. (2019), and Paruntu et al. (2018) which states that the PjBL learning model influences communication skills. This is due to the environmental change learning tools based on STEM-PjBL that trains students to be able to develop communication skills including project discussion activities, project implementation, and percentage of project results that are in accordance with STEM aspects, thus requiring students to be able to appear to explore their communication abilities. Instructions obtained at PjBL with the STEM approach can improve student learning outcomes and are able to improve student vocabulary and standards in communication (Bicer et al., 2015). According to Umar (2012), good communication skills will make students tend to more easily adapt to whoever the student is, both in a community and in the community, which will bring students success in their lives.

All learning outcomes obtained by students in this study are inseparable from the teacher's activities during the learning activities taking place. In addition, the integration of STEM in learning also affects the ability of 4C students which is proven based on the results of this study. This is in accordance with Asri (2018) which states that learning that is grown through STEM can improve the ability to think logically, creatively, innovatively, problem solving, and the ability to work in teams. Thus, STEM learning tools should be able to continue and be developed by teachers and other researchers.

## CONCLUSION

In this study it has been proven that environment change learning tools based on STEM-PjBL is effective on students' 4C skills. Therefore, to be able to optimally improve 4C

skills, it is necessary to make a habit of improving students' 4C skills in each learning activity through STEM-PjBL learning. With the habit of using STEM-PjBL learning, it is possible for students to have better 4C skills.

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