

STUDY OF STEM LEARNING APPROACH WITH PjBL MODEL IN HONING CREATIVE THINKING SKILLS

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Abstract: STEM (Science, Technology, Engineering, and Mathematics) is an interdisciplinary approach that studies academic concepts related to the real world. The principles of Science, Technology, Engineering and Mathematics are essential for connecting schools, communities, work and the global world. These principles can be implemented into a project-based learning model (PjBL) in the form of measurable learning steps. The PjBl model is believed to be able to develop students' thinking skills, develop students' creativity, and encourage students to work together in teams. The purpose of writing this article is to describe and provide an overview of several things related to STEM as an approach that can integrate knowledge, technology, techniques and mathematics as well as the implementation design of the STEM learning approach with the PjBL model to improve students' mathematical creative thinking in learning mathematics. In this study, the author uses the type/approach of research in the form of library research. The results of the study show that the STEM approach with the PjBL model students can be trained to create learning based on problems of everyday life so that they can train students in applying the knowledge learned in school with phenomena that occur in the real world. The PjBL model is also able to provide early research experience through project work concepts that are built on the products produced.

Keywords: STEM Approach, PjBL Model, Creative Thinking Skills

INTRODUCTION

Developing the potential of students in creating ideas in science is not an easy endeavor. In order to develop the scientific and technological potential of students today, it is necessary to increase abilities in various fields of education (Suyanto *et al.*, 2012). One area that needs to be improved is the field of Natural Sciences. This is in line with (Murnawianto *et al.*, 2017). which states that science education can improve the thinking skills needed in the 21st century. In order to realize quality human resources, the younger generation must of course also have several competencies or expertise. These competencies must be mastered and possessed by every human being so that they are able to face life in the 21st century. Along with that, there are demands in the 21st century; the skills that must be possessed by students are the 7Cs which include critical thinking and problem solving, creativity and innovation, collaboration teamwork and leadership, cross-cultural understanding, communications information, and media literacy, computing and ICT literacy, career and learning self-reliance. One of the skills that gets a lot of attention is creative thinking skills so that they can make products with their ideas and ideas (Zubaidah, 2016; Palennari, 2022) which every modern human being must have (Fonseca, 2018; Sukardi *et al.*, 2019).

According to Rhodes (1961), creativity is analyzing four dimensions known as "the Four P's of Creativity" or the four Ps of creativity, namely person, product, process, and press (Mulyana *et al.*, 2019; Herlangga *et al.*, 2021). First, creativity as a person illustrates individuals with their unique thoughts or expressions. Second, creativity as a product is a new, original, and meaningful creation. Third, creativity as a process reflects skills in thinking which include: fluency, flexibility, originality, and elaboration. Fourth, creativity as a press is an internal or external condition that encourages the emergence of creative thinking.

One of the skills needed is creative thinking skills. By applying creative thinking skills students are able to create bright ideas or ideas. In the process of creating products, students also need creative thinking skills. Creative thinking skills are used mainly in introducing problems and designing experiments, so they are needed by students

(Wahono *et al.*, 2020). Creative thinking skills are also needed to propose alternative problem solving (Pramesti *et al.*, 2022). To solve a problem, it is not enough to rely solely on intelligence, but also to use creative thinking. However, students' creative thinking skills are still lacking.

Learning methods that are able to apply honing creative thinking skills so as to produce products are project-based learning. In simple terms, project-based learning is defined as a teaching process to connect technology and everyday life problems that are familiar to students or school projects. Bedard *et al.*, 2012 and Yuset *et al.*, 2020 mentions that project-based learning methods are able to develop students' thinking skills, develop students' creativity, and encourage students to work together in teams.

In addition to project-based learning, current learning needs to keep up with the times. In the era of globalization, one of them is by integrating Science, Technology, Engineering, and Mathematics (STEM). According to (EL-Deghaidy *et al.*, 2017) said that STEM is an interdisciplinary approach that studies academic concepts related to the real world. Nguyen *et al.*, 2020 says by applying the principles of science, mathematics, engineering and technology, it is wise to make connections between schools, communities, work, and the global world. The STEM model also provides space for the development of STEM literacy. So that they have the ability to compete in the new economic world (Potvin & Hasni, 2014). The relationship between science and technology with other sciences cannot be separated in science learning. STEM is a discipline that is closely related to one another. Science requires mathematics as a tool in processing data. Technology and engineering are applications of science. The STEM approach in learning is expected to produce meaningful learning.

Research on the integration of STEM in project-based learning is still rarely done. The results of the study (Afriana *et al.*, 2016) revealed that STEM-integrated project-based learning can increase students' interest in learning, make learning more meaningful, help students solve real-life problems, and support future careers. In addition, STEM in project-based learning poses challenges and motivates students to practice critical thinking, analyze, and improve higher order thinking skills (Sukmawijaya *et al.*, 2019).

In several articles, research results show that the STEM approach with the PjBL learning model is able to improve students' creative thinking in science learning. This is one of the reasons that prompted the author to conduct a literature review on the discussion. In this paper, the author tries to describe and provide an overview of several things related to STEM as an approach that can integrate knowledge, technology, engineering and mathematics as well as the design of implementing the STEM learning approach with the PjBL model to improve students' creative thinking in science learning.

MATERIAL AND METHOD

In this study, the author uses the type/approach of research in the form of library research. Literature research is a study by reviewing or collecting information and data with the help of various books, journals, papers, articles, dissertations, theses, and other scientific works cited in writing proposals related to the problem to be solved or being discussed (Syafitri&Nuryono, 2020; Christiana, 2020). According to Anindayati&Wahyudi (2020) library research is all efforts made by researchers to collect information relevant to the topic or problem that will be or is being studied. The literature review research in this discussion aims to inform, analyze, combine and interpret concepts from the results of previous research studies that are closely related to the study being discussed.

This literature review method is used to develop concepts regarding the STEM approach with the PjBL model to improve students' creative thinking in science learning. The steps in writing this literature review according to Sari & Asmendri (2018) are topic selection, information exploration, determining the focus of the study, collecting data sources. preparation of data presentation, and preparation of reports. The data analysis technique used in this study is the content analysis method. This analysis is used to obtain valid inferences and can be re-examined based on the context (Krippendorff, 1933).

RESULT AND DISCUSSION

Science, Technology, Engineering, Mathematics (STEM)

STEM was originally formed in 1990 at the National Science Foundation (NSF). STEM describes the general policy of the problem of continuing education, especially at the national and state levels of America. Nuraeni *et al.*, 2021;

Priyantini *et al.*, 2021; Anggraini & Huzaifah, 2017 said the STEM approach is an approach that links and integrates STEM subjects in order to create problem-based learning in everyday life, so that they can train students in applying the knowledge learned in school with phenomena that occur in the real world.

According to Mulyana *et al.*, (2018) STEM is an approach that integrates four disciplines, namely science, technology, engineering, and mathematics by focusing the educational process on solving real problems in everyday life. The STEM approach is able to create a cohesive learning system and active learning because all four aspects are needed simultaneously to solve problems (Sukmana, 2018) Therefore, in the learning process STEM as a learning approach may not fulfill all elements of the STEM discipline, it is allowed if there are only two or three elements fulfilled in a learning activity.

STEM education means providing practical strengthening of education in STEM fields separately, as well as developing an educational approach that integrates science, technology, engineering, and mathematics, by focusing the educational process on solving real problems in everyday life or professional life. According to (Mulyani, 2019) the basic definition of each word is STEM, namely:

1. Science: is part of the knowledge that is learned from the universe, the facts of the phenomenon and the regularities that exist in it.
2. Technology: created as a change innovation, modification of the natural environment to provide satisfaction to human needs and desires.
3. Engineering: consists of determining the problem (asking), imagining, designing (planning), making (creating), and developing (improving)
4. Mathematics: a branch of the discipline that studies patterns or relationships.

STEM education offers educators the opportunity to introduce students to the concepts, principles and techniques of science, technology, engineering, and mathematics. It is applied in an integrated manner to the development of products, processes and systems that are used in everyday life. STEM-based learners are expected to be able to use science, technology, engineering, and mathematics in real-world contexts that link school, work, and the global world to help students compete in a new knowledge-based era. STEM inclusive education does not only focus on development but also empowers Science, Technology, Engineering/Design, and Mathematics students to develop soft skills, such as finding new innovations in the field contextually.

Project Based Learning

According to Anggraini *et al.*, (2019) & Afriana *et al.*, (2016) Project based learning is a complex task based on problems that can involve students so that they can work together in groups so that they get results, namely real products that can be presented. Furthermore, PjBL is a learning process that involves students to produce a project (Anggraini & Sari, 2017). This learning method uses projects as learning media and is assessed in line with government regulations, where students will be required to explore, assess, interpret, synthesize, and provide information to produce various forms of learning outcomes (Pratama & Prastyaningrum, 2016). Therefore, a learning model that makes a project a learning medium. Students will be given the opportunity to work or study using a project, which means that students will be given the opportunity to explore and find various information to solve a problem in order to produce a product.

Global School Net reports on the results of the AutoDesk Foundation's research on the characteristics of PjBL. The results of the study stated that PjBL is a learning approach that has the following characteristics:

1. Learners make decisions about a framework
2. There are problems or challenges posed to students
3. Students design processes to determine solutions to problems or challenges posed
4. Students are collaboratively responsible for accessing and managing information to solve problems
5. The evaluation process is carried out continuously
6. Students periodically reflect on the activities that have been carried out
7. The final product of the learning activity will be evaluated qualitatively
8. The learning situation is very tolerant of mistakes and changes

The PjBL - STEM learning process in guiding students consists of five steps, each step aims to achieve a specific process. The following are the stages in the effective PjBL-STEM learning process (Rahmania, 2021).

Stage 1: Reflection

The purpose of the first stage is to bring students into the context of the problem and provide inspiration to students so that they can immediately start investigating.

Stage 2: Research

The second stage is a form of student research. The teacher provides science lessons, selects literature, or other methods to gather relevant sources of information. The learning process occurs more during this stage, students' learning progress concretizes the abstract understanding of the problem.

Stage 3: Discovery

The discovery phase generally involves the process of bridging the research and information that is known in the preparation of the project. When students begin to learn independently and determine what is still unknown. Some models of STEM-PjBL divide students into small groups to present possible solutions to problems, collaborate, and build cooperation among friends in groups. Another model uses this step in developing the ability of students to build a habit of mind from the process of designing to designing.

Stage 4: Application

At the application stage the goal is to test the product/solution in solving the problem. In another model, at this stage students learn a wider context outside of STEM or the link between STEM disciplines.

Stage 5: Communication

The final stage in each project is to create a product/solution by communicating between friends and the class. Presentation is an important step in the learning process to develop communication and collaboration skills as well as the ability to receive and apply constructive feedback.

The Project Based Learning model uses projects in groups and between groups that lead to student communication through the syntax of evaluating data, arriving a conclusion, presenting the project in class preferred and discussion (Saputro & Rayahub, 2020). One of the goals of the Project Based Learning (PjBL) model is to improve students' ability to solve project problems, acquire new knowledge and skills in learning and make students more active and creative in solving complex project problems with real product results (Sari *et al.*, 2022). So that this learning model will train students to become responsible, communicative, collaborative individuals and increase students' creativity in solving a problem.

Creative Thinking

Creative thinking is a mental activity that produces something new as a result of development. This is in accordance with the opinion of Coleman and Hammen Muzaki, (2012); Fadlan *et al.*, (2020); Fadlan *et al.*, (2020); Istianah, (2013) that "Creative thinking is a mental activity to increase originality and insight in developing something (generating)". The ability to think creatively is related to the ability to produce or develop something new, something unusual that is different from the ideas generated by most people. According to (Fahrudin, 2017) creative thinking ability can be measured by indicators of creative thinking ability which is divided into four things, namely:

1. Fluency is the ability to generate many ideas in solving problems, provide many ways or suggestions for doing things, work faster and do more than others.
2. Flexibility is the ability to present various solutions or answers to problems, can see a problem from different perspectives, and present a concept in a different way.
3. Originality, is the ability to generate ideas in ways that are original, not clichéd, and rarely given by most people.
4. Elaboration (elaboration), is the ability to develop or enrich a situation or other people's ideas so that they become complete and improve the quality of these ideas, and detail them in detail in the form of tables, graphs, pictures, models and words.

According to Kurniawati (2018) measuring students' creative thinking skills can be done by exploring students' work that represents their creative thinking process. Meanwhile, according to McGregor (2007) in Yudi *et al.*, (2017)

measuring students' creative thinking skills can also be done by basing on what students communicate, verbally and in writing. What the students communicated can be in the form of student work related to assignments, problem solving, or students' verbal answers to teacher questions.

Implementation of STEM with PjBL Learning Methods in Honing Creative Thinking Skills.

The rapid development of the times has led us to prepare ourselves as best we can to face it. One of them is to prepare the next generation who are literate in STEM fields. Because in the field of education, the STEM approach can be used to prepare students so that they are able to think creatively, compete and are ready to work according to their expertise so that they can provide new innovations. Learning using a direct STEM approach is the best way to provide training for students to be able to integrate each aspect at once.

Description of learning by integrating the STEM approach with the Laboy-Rush PjBL model can be obtained a learning experience that is able to hone students' creative thinking skills. This is illustrated in Table 2.

Table 2. Learning Description

PjBL Stages	STEM	Indicator of Creative Thinking Ability
Stage 1. Reflection Students are asked to relate what is known to what will be learned.	<ul style="list-style-type: none"> • Knowledge (Science) 	<ul style="list-style-type: none"> • Fluency • Flexibility • Authenticity (originality)
Stage 2. Research Students are able to collect relevant sources of information related to what is being studied	<ul style="list-style-type: none"> • Knowledge (Science) • Technology (Technology) 	<ul style="list-style-type: none"> • Fluency • Flexibility • Authenticity (originality)
Stage 3. Discovery Students carry out the process of designing / designing products.	<ul style="list-style-type: none"> • Knowledge (Science) • Technology (Technology) • Engineering (Engineering) • Mathematics (Mathematics) 	<ul style="list-style-type: none"> • Fluency • Flexibility • Authenticity (originality) • Elaboration (elaboration)
Stage 4. Application Students make and test products and repair products when the product is not in accordance with the previous provisions.	<ul style="list-style-type: none"> • Knowledge (Science) • Technology (Technology) • Engineering (Engineering) • Mathematics (Mathematics) 	<ul style="list-style-type: none"> • Fluency • Flexibility • Authenticity (originality) • Elaboration (elaboration)
Stage 5. Communication Students present their products. As well as being able to receive constructive feedback	<ul style="list-style-type: none"> • Knowledge (Science) • Technology (Technology) • Engineering (Engineering) 	<ul style="list-style-type: none"> • Fluency • Flexibility • Authenticity (originality) • Elaboration (elaboration)

The implementation of STEM learning leads to a shift in learning from teacher-centered learning to student-centered learning. PjBL learning or project-based learning can increase student interest because of the involvement of students in solving authentic problems, working with groups and building solutions to real problems. The application of the STEM PjBL model will be very beneficial because it involves students to think on complex problems that hone their creative thinking power. In this study, PjBL STEM learning is used to guide students in which each step aims to achieve a specific process. According to LaboyRush, there are five steps in implementing PjBL-STEM learning, including: (1) reflection, (2) research, (3) discovery, (4) application, and (5) communication. Through learning with these steps, students bring out a lot of creativity and skills such as (time management, collaboration and problem solving).

PjBL STEM learning allows students to hone their creative thinking skills. In PjBL STEM learning, students can practice creative thinking aspects, including: flexibility in thinking about various ways to solve problems or being

able to solve problems from various points of view, fluency in expressing ideas, authenticity in creating an unthinkable innovation. by others and the elaboration or ability to develop other people's ideas. The concept of project work in the PjBL learning model is built based on the resulting product. Besides, the existence of knowledge, technology, engineering and mathematics is needed in creating creative projects/products.

CONCLUSION

The STEM approach is an approach that combines and links four fields of science, namely science, technology, engineering and mathematics. The combination of the STEM approach with the PjBL model can hone students' creative thinking skills. Because in the STEM approach with the PjBL model studentstrained to create learning based on problems of everyday life so that they can train students in applying the knowledge learned in school with phenomena that occur in the real world. The concept of project work in the PjBL learning model is built based on the resulting product. Besides, the existence of knowledge, technology, engineering and mathematics is needed in creating creative projects/products. Thus the combination of the STEM approach with the PjBL model can optimize learning activities that support students in achieving learning success and creative thinking skills. Thus, STEM-based learning with the PjBL model is one of the lessons that has the potential to be used to build 21st century skills.

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