Mathematics Education Journals
Vol. 6 No. 2 August 2022

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Systematic Literature Review: STEM Approach through Engineering Design Process with Project Based Learning Model to Improve Mathematical Creative Thinking Skills

Maydilla Fadiarahma Vistara[1], Rochmad[2], Kritina Wijayanti[3]

[1,2,3] Mathematics Education Department, Semarang State University
E-mail: maydillaf@students.unnes.ac.id

Abstract

The STEM approach is a learning approach that allows students to think creatively. Creative thinking is included in the skills of the 21st century, especially the 4C ability that students must have to be able to compete globally. This research aims to describe the STEM approach through EDP with the PjBL model and examine the impact of implementing STEM approaches through EDP with the PjBL model on students' creative thinking skills. This research is qualitative research conducted using literature studies. Data collection in this study was carried out by reviewing articles in national and international journals. STEM-EDP implementation with project-based learning can be done in group learning. The results of the study by referring to previous research related to STEM-EDP with project-based learning can be concluded that STEM-based project-based engineering through engineering design processes are able to provide influence to improve students' creative thinking skills.

Keywords: PjBL; EDP; mathematical creative thinking; STEM

INTRODUCTION

Improvements and innovations are continuously carried out in education so that students in Indonesia are able to face the progress of the times and global competition. Mathematics is an exact science that requires more creative thinking skills than memorization (Abidin et al., 2018). According to the global innovation index 2021, Indonesia is ranked 87 out of 132 countries (Soumitra et al., 2021). Innovation is related to the creative thinking process, innovation is generated through the creative thinking process (Amala & Ekawati, 2020). An essential skill that is important and must be possessed by students at every level of education is the ability to think creatively (Monica et al., 2021).

Creative thingking is needed to solve the mathematical problems. Students' mathematical creative thinking skills include 4 aspects, namely aspects of fluency (*fiuency*), authenticity (*originality*), *flexibility (flexibility*), and detail (*elaboration*) (Saironi & Sukestiyarno, 2017). Mathematical creative thinking is a combination of logical thinking and divergent thinking based on intuition but still in consciousness (Siswono, 2015). The development of mathematical creative thinking can be optimized through the role of educators (Tubb et al., 2020). Through the right approach to mathematical creative thinking students are able to produce thought with many solutions (Sriraman, 2017). Educators need to use

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

appropriate approaches and models so that students' creative thinking skills can be developed.

STEM integrated learning is one of the appropriate approaches to be applied in the learning process as an effort to cultivate 4C skills (critical thinking, creativity, collaboration and communication) (Fajrina et al., 2020). According to Laboy Rush in Pratika Surya & Wahyudi (2018) stem integration program in learning is an innovation learning program that combines two or more fields of science contained in science, technology, engineering and mathematics. The STEM approach is thought to have the potential to help students to solve new problems and draw conclusions based on previously learned principles from fields such as science, technology, engineering and mathematics (Daugherty & Carter, 2018).

Engineering design process as a pendagogis strategy to integrate STEM into learning to solve open problems, develop creative thinking, formulate solutions, make decisions, and consider alternative solutions to meet various obstacles (Shahali et al., 2017). EDP encourages students to think creatively and offers an effective route as an instructional framework for implementing STEM (Siew, 2017). According to EDP is a systematic and intelligent process that generates, evaluates and determines concepts for achieving learning goals (K. Y. Lin et al., 2021). EDP is one of the new ideas discovered to guide the development of learning in schools (Yousef Haik, 2011).

Creative thinking skills can be generated through appropriate learning models (Lestari & Sumarti, 2018). Project Based Learning is product-based learning, PjBL facilitates students to collaborate in conceptual understanding, apply prior knowledge and gain skills (Ummah et al., 2019). PjBL can integrate several disciplines to create a project. PjBL uses a real production model so as to encourage students to think in solving the problems faced (Remijan, 2016). Project based learning is one of the learning models where students are given the freedom to plan learning activities, carry out projects in groups, and produce products that are presented (Nawang Sari et al., 2021).

Research questions related to the purpose of the research as well as the background that has been outlined are as follows: How does STEM approach through EDP; How does the STEM approach integrate through EDP with the PjBL model; How does the implementation of STEM approaches through EDP impact with the PjBL model to improve mathematical creative thinking skills. Using the Systematic Literature Review method, researchers do literacy from various studies that have been done. This research is done by collecting data from various sources or documents through journal articles or other scientific works that are considered relevant to obtain research data.

RESEARCH METHOD

Research uses Systematic Literature Review (SLR) which is a research method that summarizes the results of primary research to present more comprehensive and balanced facts. The SLR method can systematically identify journals, which in each process follow established steps or protocols. SlR aims to comprehensively find and synthesize research that draws on specific questions, using procedures that are

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

organized, transparent, and can be replicated at every step in the process (Rahmawati & Juandi, 2022). Related to STEM, EDP, PjBL models and mathematical creative thinking skills of SLR students are conducted to identify, critically evaluate and summarize the findings of all relevant studies describing learning and teaching.

Steps in the SLR include developing research questions (formulating research questions), developing the search strategy (looking for articles or literature that fit the research theme), selection criteria (applying inclusion criteria to select articles), evaluation and analyse data (evaluating and analyzing data) and interpreting (reporting research findings) (Putra & Roza, 2020) . Researchers collect journal articles on the Google Scholar database with the help of the Publish or Perish app. Keywords are STEM, EDP, PjBL model and mathematical creative thinking skills. The collected articles are only articles published in the period 2017 to 2022. The collected articles come from national and international journals. Out of 47 articles, researchers selected 27 articles that were closely aligned with the keywords used.

The next step is to select and evaluate the article. At this stage, the selection of articles that enter the inclusion criteria is carried out. Only articles that are relevant and meet the criteria of inclusion will be (Kong Suik, 2020). Articles that do not fit the inclusion criteria are not included in the next stage. Selected articles that enter the inclusion criteria are then coded and sorted according to relevance to the theme for analysis. The final step is to report the results of the research findings. In this step, a systematic and clear report is made on the results of the study.

RESULTS AND DISCUSSION

Tabulation of STEM-related documented article data is presented in Table 1 below.

Table 1 STEM-related research

Author / Journal	Heading	Research Objectives	Research Results
Marco-bujosa, (2021)/ International Journal of Technology in Education	Prospective Secondary Math Teachers Encountering STEM in a Methods Course: When Math is More Than "Just Math"	Mexplores how incorporating STEM into educational teachers can promote STEM teaching as well as improve math instruction.	STEM learning helps students conceptual understanding and the ability to connect, skills that drive student math learning
Glaze-Crampes, (2020)/ Education science	Leveraging Communities of Practice as Professional Learning Communities in Science, Technology, Engineering, Math (STEM) Education	Define goals, roles and expectations in STEM.	STEM education is nothing new, there is still a lot of work needed to clearly define the field, increase interest and retain students.
Brown & Bogiages, (2019)/ Int J of Sci and Math Educ	Professional Development Through STEM Integration: How Early Career Math and Science Teachers Respond to	Mexplores the various early positions of high school science and math teachers from across the U.S. who are co-engaged as	Rmoney classes will add to our understanding of the ease and challenges of using STEM.

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

	Experiencing Integrated STEM Tasks	learners in science, technology, engineering, and mathematics (STEM).	
Fong & Kremer, (2020)/ Gifted Child Quarterly	An Expectancy-Value Approach to Math Underachievement: Examining High School Achievement, College Attendance, and STEM Interest	Highschool students' low math achievement, motivation, and impact on future math achievement, college attendance, and STEM (science, technology, engineering, and math).	Our findings point to important implications for policy and practice education.
L. Lin et al., (2018)/ frontiers in psychology	Math Self-Efficacy and STEM Intentions: A Person-Centered Approach	Mexamines the impact of mathematical self-efficacy and various distal predictors, such as individual demographic information, beliefs about mathematics, and social group identification, on STEM interests and intentions.	Mathematics is self-efficacy in major choice as well as overall academic performance regardless of whether a student is in a STEM field or a non-STEM field.
Wang et al., (2017)/ EMPIRICAL RESEARCH	Who Chooses STEM Careers? Using A Relative Cognitive Strength and Interest Model to Predict Careers in Science, Technology, Engineering, and Mathematics	Relativecognitive strength and interest in math, science, and the verbal domain in high school are more accurate predictors of STEM career decisions.	Pemuda with asymmetric cognitive ability profiles are more likely to choose careers that utilize their cognitive strengths over their weaknesses, while cognitive symmetric ability profiles can give youth more flexibility in choice, allowing their interests and values to guide STEM career decisions.
Daugherty & Carter, (2018)/ Handbook of Technology Education	The Nature of Interdisciplinary STEM Education	Know STEM with a problem-centric approach to STEM careers.	Disiplin STEM through integrated and problem-centered learning activities.

Tabulation of documented article data related to EDP articles is presented in table 2 below.

Table 2 EDP-related research

Author / Journal	Heading	Research Objectives	Research Results

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Shahali et al., (2017)/ EURASIA Journal of Mathematics Science and Technology Education	STEM Learning through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM	It revealed that, overall there was a significant increase in average scores for interest in STEM and career subjects after participating through EDP.	Such EDP programs are effective in modifying students' interest levels as a result of demonstrating positive changes (from moderate to high level) to interest in their respective careers and interest in STEM subjects.
Siew, (2017)/ The Eurasia Proceedings of Educational & Social Sciences	Integrating STEM in An Enginnering Design Process The Learning Experience of Rural Secondary School Students in An Outreach Challenge Program	Evaluate the learning experience of tenth graders from two classes of Malaysian rural high schools who adopt STEM integration in Engineering Design Processes (STEM-EDP)	The STEM-EDP approach can be applied as a means to foster creativity, problem-solving skills, and thinking skills among rural high school students.
K. Y. Lin et al., (2021)/ International Journal of STEM Education	Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking	Investigate the cognitive structure of preservice technology teachers and how they build engineering design in technology learning activities and explore the effects of embedding engineering design processes into project-based learning of science, technology, engineering, and mathematics (STEM) to develop cognitive structures of preservice technology teachers for EDP thinking.	The EDP to STEM project-based learning process is beneficial for developing thought schemes, encouraging teachers to further explore the systematic concepts of engineering design thinking and expanding their capabilities by incorporating engineering design processes into STEM project-based learning.
Sen et al., (2021)/ Elsevier	Computational thinking skills of gifted and talented students in integrated STEM activities based on the engineering design process: The case of robotics and 3D robot modeling	Identify computational thinking skills used by gifted and talented students in EDP-based integrated STEM activities.	Integrated STEM activities are based on: EDP actively utilizes critical thinking skills while providing explanations, making associations, questioning information, providing justification, solving problems, thinking creatively, making generalizations, and

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

			trying to convince others.
Siew, (2022)/ International Journal of Teaching and Learning	Exploring students' STEM Imagination Process Through An Engineering Design Process	Explore the imagination of STEM Class 10 students from one rural Malaysian high school who adopt the integration of imagination processes in the Engineering Design Process (EDP) through programs in STEM.	The EDP approach is able to create a supportive environment to nurture the IMAGINATION of STEM among rural high school students.
Kotseva, (2019)/ S cience, Engineering & Educat	Engineering Design-Based Learning in Integrative STEM Education	Explore the characteristics of engineering design and discover how it interacts with science, technology, and mathematics in STEM classrooms.	STEM EDP is not intended to replace the study of individual disciplines, but rather to support and complement it through all formal and Informal means wherever possible.

Tabulation of documented article data related to the article is presented in table 3 below.

Table 3 PjBL-related research

Author / Journal	Heading	Research Objectives	Research Results
Lestari & Sumarti, (2018)/ Journal of Primary Education	STEM-Based Project Based Learning Model to Increase Science Process and Creative Thinking Skills of 5th Grade	Know the effects of STEM-based project-based learning models on science process skills and creative thinking.	STEM project-based learning models can improve science process skills and creative thinking
Ummah et al., (2019)/ Journal on Mathematics Education	Creating Manipulatives: Improving Students' Creativity Through Project Based Learning	Describe the implementation of project-based learning models and analyze student creativity improvements	There is an increase in student creativity in project-based learning implementation of learning. Flexibility and good novelty.
Lou et al., (2017)/ EURASIA Journal of Mathematics Science and Technology Education	A Study of Creativity in CaC2 Steamship-derived STEM Project-based Learning	Explore the effects of project-based learning (PBL) integrated into science, technology, engineering, and mathematics (STEM) activities and to analyze the creativity that junior high school students display while performing activities.	STEM project-based learning can further develop affective domains of creativity, including adventure, curiosity, imagination and challenge.

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Remijan, (2016)/ The Interdisciplinary Journal of Problem-based Learning	Project-Based Learning and Design-Focused Projects to Motivate Secondary Mathematics Students	Illustrate how math teachers can develop design-focused projects, related to project-based learning, to motivate intermediate math students.	Maps a personal insight into how design-focused projects can be perceived to increase students' motivation in math classes
Edmunds et al., (2017)/ The Interdisciplinary Journal of Problem-based Learning	The Relationship Between Project-Based Learning and Rigor in STEM-Focused High Schools	Explore the relationship between PjBL and rigor in the classrooms of ten STEM-oriented high schools.	Academic rigor can be present in the absence of PjBL, and that PjBL can be implemented with a low level of rigor.
Aldabbus, (2018)/ International Journal of Education, Learning and Development	Project Based Learning: Implementation & Challenges	Explore the challenges that may occur during the implementation of project-based learning in actual classroom situations.	Offers a good opportunity for researchers to assist in facilitating the process of implementing project-based learning.
Chen & Yang, (2019)/ Educational Research Review	Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators	Compare the effects of project-based learning and traditional learning on students of academic achievement.	Demonstrates that project-based learning has a moderate to large positive influence on student learning outcomes. Academic performance compared to traditional instruction.

Tabulation of documented article data related to mathematical creative thinking articles is presented in table 4 below.

Table 4 Research related to mathematical creative thinking

Author / Journal	Heading	Research Objectives	Research Results
Khalid et al., (2020)/ Creativity studies	Enchancing Creativity and Problem Solving Skills Through Creative Problem Solving in Teaching Mathematics	Foster creativity through the teaching of mathematics through problem solving that challenges problem solving in creative ways, defined as creative problem solving.	Statistically significant score improvements for most creativity categories and problem-solving tests.
Supandi et al., (2021)/ Hindawi Education	Learning barriers and student creativity in solving math problems	Foster student creativity and innovation in understanding the case of differential application of equations.	The learning and evaluation approach using story questions improves students' mathematical ability of imagination in education.

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Kovari & Rajcsanyi-Molnar, (2020)/ Acta Polytechnica Hungarica	Mathability and Creative Problem Solving in the MaTech Math Competition	Develop creativity, creative problem solving, teamwork, and apply digital knowledge in real math problems	In addition to knowledge, skill improvement that requires creative presentation should also be considered.
Joklitschke et al., (2018)/ IEJME	Theories About Mathematical Creativity in Contemporary Research	Systematic analysis of theoretical background in articles on mathematical creativity	Creativity to focus more on different approaches. Proper theoretical basics are essential for research
Jawad et al., (2021)/ International Journal of Interactive Mobile Technologies	The Impact of Teaching by Using STEM Approach in The Development of Creative Thinking and Mathematical Achievement	Know the influence of science, technology, engineering, and mathematics education on creative thinking and mathematical achievement.	Learning using STEM approaches can generate new ideas, create work that has not existed before, thus encouraging students to innovate and enhancing creativity and achievement.
Parno et al., (2019)/ International Journal of Recent Technology and Engineering (IJRTE)	The Influence of STEM- Based 7E Learning Cycle on Students Critical and Creative Thinking Skills	Identify the effects of a teaching approach called the STEM-7E learning cycle on critical thinking skills and creative thinking skills.	STEM learning teaching is capable of enhancing critical thinking and creative thinking skills.
Husna et al., (2020)/ Scientiae Educatia	Developing STEM-Based Students Worksheet to Improve Students' Creativity and Motivation of Learning Science	Observe and modify STEM-based LKS to enhance students' motivation and learning creativity.	The implementation of developed STEM-based LKS can significantly increase students' motivation and creativity.

STEM approach through EDP

STEM education has the potential to prepare students with the skills and mindset to face complex global challenges (Marco-bujosa, 2021)(Marco-bujosa, 2021). Teacher preparation needs to be done in order to integrate STEM into learning. STEM education represents a variety of challenges, including the involvement of four different areas of study. Kinvolvement in STEM and leading to large-scale reforms (Glaze-Crampes, 2020). Research by L. Lin et al., (2018) found participantswere asked to show interest in STEM-related activities on a scale from 1 (Very Disliked) to 5 (Very Liked). The list of STEM-related activities includes "solving math or practical science problems", "reading" articles or books about scientific problems," and "solving computers" software problems." Higher scores indicated that participants had a higher interest in STEM-related activities. Alfa Cronbach for interest in STEM activities is 0.87.

Relative recognition abilitiesprovide a more nuanced view of how abilities and interests shape the path to a STEM career (Wang et al., 2017). By nurturing students' STEM imaginations, science educators can prepare students to become

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

more creative thinkers and problem solvers who possess the skills and skills necessary to address problems and problems encountered on an everyday level in new and innovative ways (Siew, 2022).

Engineering Design Process supports an interdisciplinary approach that combines knowledge of science, mathematics, engineering and technology, as well as problem solving, creative thinking, and communication skills (Shahali et al., 2017). Shahali et al., (2017) stated that theimplementation of the engineering design process in the module is based on: five cycles as; (1) ask, (2) imagine, (3) create, (4) test, and (5)improve. The application of STEM content knowledge during the design process will be a key component of learning. Presented in the image as follows.

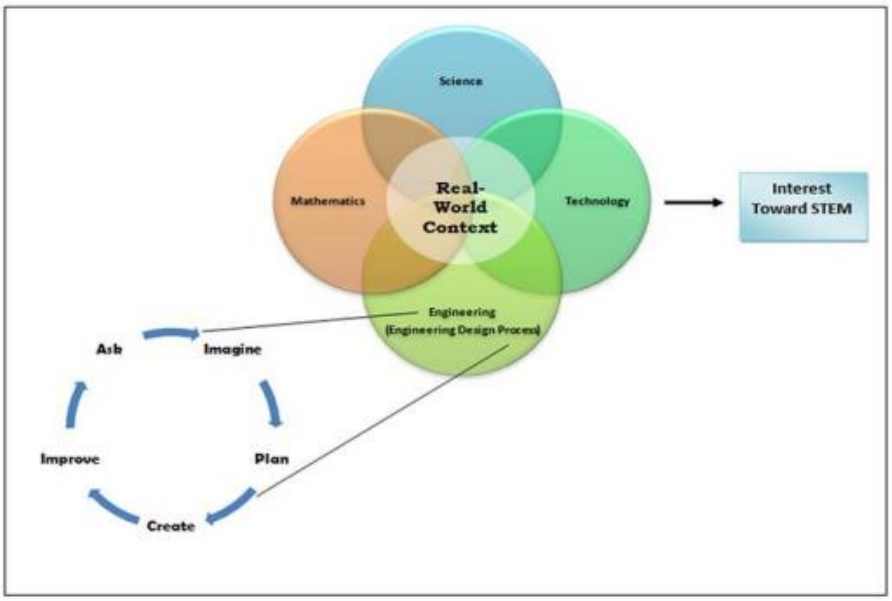

Figure 1. Engineering Design Cycle

Students are also able to connect STEM activities with everyday life and scientific concepts learned in the classroom, and to create new and practical products using everyday materials. Research (Siew, 2017) explains that the implementation of the proposed STEM-EDP program can assist students in connecting STEM knowledge with real-world problems and contexts. Stem-EDP outreach challenge programs not only enable students to gain and integrate STEM knowledge but also provide avenues to enhance their creativity, critical thinking, and problem-solving skills.

Students are considered to have taken advantage of the EDP-STEM environment and the flow of its activities while realizing their original thoughts and ideas. Discussion and brainstorming sessions are held to express students' opinions throughout the activity, which encourages students to express their thoughts. The EDP-STEM activity process is carried out in a way that allows students to be free when expressing their opinions and reflecting these opinions on their products. Therefore, each student is able to express his ideas and opinions (Sen et al., 2021). Supporting students in creating unique designs and products, these activities help

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

them demonstrate creativity. The EDP approach, students are able to formulate concise ideas capable of solving problems related to everyday life, despite inadequate scientific and technical knowledge. The EDP approach can create environmental support to nurture stem imagination among high school students (Siew, 2017).

Integration of STEM approaches through EDP with PjBL models

According to Lestari & Sumarti's research, (2018) the difference between grades after and before treatment, the advantages showed an improvement in students' creative thinking skills after using STEM-based PjBL. Presented in the following Figure 2.

Score	Criteria	Total	%
N-gain ≥ 0,70	High	7	23
0,30 ≤ N-gain < 0,70	Fair	24	77
N-gain < 0,30	Low	-	-
Total			100

Figure 2. Experimental Class Test Results

STEM based PjBL students to be more active and responsive in facing problems in the environment, such as and more creative. Through STEM-based projects based on learning models, students are able to define learning concepts and connect them with real life. STEM based PjBL are able to exert influence to improve students' creative thinking skills. Teachers should examine questions, problem-solving activities, and assignments in projects to ensure that they require students to engage at a higher level of thinking such as analyzing, synthesizing, evaluating, or creating (Edmunds et al., 2017).

Yustina et al., (2020) research found that overall the average creative thinking score of students in class experiments was 91 with an N-gain index of 0.62 higher (very creative) compared to in control class (76) with an N-gain index of 0.51 (quite creative). Mixed Learning and PjBL are quite influential in improving the creativity of thinking skills, quite more effective than conventional learning in improving creative thinking.

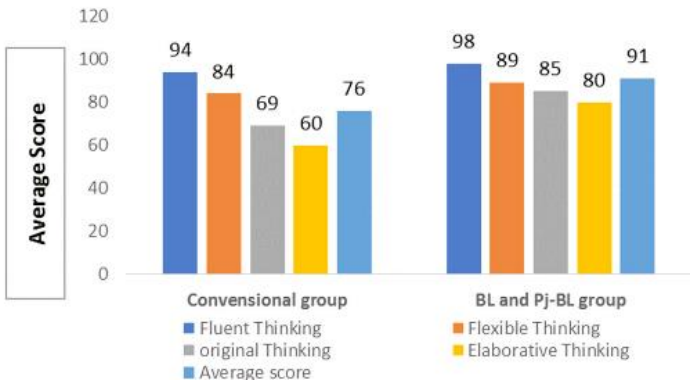

Figure 3. Histogram Posttest Project Based Learning

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

The results of Chen & Yang's research, (2019) show that PjBL can be an effective and proven alternative to direct instruction. Teachers can introduce PjBL in their "main course", as students can then be expected to have better learning outcomes than they seem. Teachers can first identify what topics important concepts and important information will be reflected on through lectures, and then incorporate them into the project.

The results of the study (Lin et al., 2021) mentioned that the experimental group for defining basic problems (i.e., the ability to clarify the scope and context of problems) increased significantly after EDP-STEM-Project Based Learning. They identify problem constraints, reconstruct problems, and summarize effective ideas. In other words, the experimental group was better able to define how project activity problems were associated with project objectives after they were taught the EDP STEM-Project Based Learning curriculum. During the teaching experiments in this study, we found that subjects also used their intuition or convergent/logical thinking to solve problems after steps of problem definition, decision-making, and objective confirmation; this may be an important factor in determining the outcome of the experiment. Furthermore, by analyzing the performance of the experimental group in more detail, we found that the experimental group was better at estimating the influence of each factor during process modeling and thus came up with the best solution; members of the experimental group can then confirm whether the solution meets the criteria set by the problem definition and review the general application of the solution.

Implementation of STEM approaches through EDP with PjBL models to improve mathematical creative thinking skills

Jawad et al., (2021) in his research obtained results that with STEM learning can develop innovative thinking, improve student achievement because with STEM learning can create an atmosphere of passion that attracts students to the field, motivates to learn, creativity and innovate. Husna et al., (2020) found the highest score on the aspect of creativity is creative in solving problems. Calculated using the percentage formula and comparing the creativity assessment category table to determine what categories are obtained. Therefore, the average percentage is 79% for the overall category. So it belongs to the good category. The results show that students have been able to develop their creative ideas.

The ability to develop creative thinking will give birth to ideas, create and imagine, and have many perspectives on something, and relate to skills in generating information, and provide more personalized learning support, encouraging independent and collaborative learning (Yustina et al., 2020).

Group	Creative Thinking	Fluent Thinking	Flexible Thinking	Original Thinking	Elaborative Thinking	Creative Thinking
Control	N-Gain Index	0.69	0.56	0.42	0.37	0.51
	Classification	Medium	Medium	Medium	Medium	Medium
Experiment	N-Gain Index	0.79	0.62	0.60	0.45	0.62
	Classification	Very High	Medium	Medium	Medium	Medium

Figure 4. Pretest Posttest Creative Thinking Skills

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

The details of the results are reviewed based on the current thinking indicator, the average score of the posttest obtained increases compared to the pretest in the control class which is from 62 to 94 on the posttest with an N-gain of 0.69. Based on the analysis of students' answers to indicators of fluent thinking ability in experimental classes, the average posttest score increased to 98 compared to the average achievement score of 60, N-gain of 0.70. The ability to think fluently tends to be very high, and then the teacher can identify and analyze the relevant literature sources, by writing and linking conclusions from studying the article and being able to provide various criteria of the article that is used appropriately using information effectively (quickly and precisely) from various sources through analysis, interpreting, assessing and synthesizing.

Yustina et al., (2020) research found that overall the average creative thinking score of students in class experiments was 91 with an N-gain index of 0.62 higher (very creative) compared to in control class (76) with an N-gain index of 0.51 (quite creative). Mixed Learning and Project-Based Learning are quite influential in improving the creativity of thinking skills, quite more effective than conventional learning in improving creative thinking. The results of the study according to (Ummah et al., 2019) project-based learning to increase student creativity, it can be concluded that there is an increase in the ability of creativity students in completing projects to create mathematics learning media based on flexibility aspects that meet the category very well. There is also an increase in students' creativity in completing mathematical learning media creation projects based on originality aspects, although some students still develop learning media with the same rules and forms as previously developed learning media.

According to research (Mathiphatikul et al., 2019) earning through STEM learning with the Engineering Design Process students develop their creative thinking continuously using learning management. Students are required to demonstrate creative thinking of behavior to identify problems, boundaries and conditions of situations. To design solutions, students need to refine and analyze their own ideas. Stem-based project-based learning models enable students to be more active and responsive in facing problems in the environment, such as and more creative than project-based learning only. Through STEM-based projects based on learning models, students are able to define learning concepts and connect them with real-life applications. Stem model-based project-based learning is able to provide influence to improve students' creative thinking skills (Lestari & Sumarti, 2018).

Experimental group engineering curriculum design process (EDP-STEM-PBL) includes engineering design processes such as modeling, feasibility analysis, and group communication; the curriculum begins with the collection of information according to the definition of the problem, followed by a feasibility analysis based on the constraints of the problem and then the selection of solutions and prototype construction (K. Y. Lin et al., 2021). Control group technology problem solving processes include problem definition, data collection, development of viable ideas, selection of the best ideas, implementation of the best ideas, evaluation of results, and revision of design ideas. The process begins with the development of knowledge and problem-solving skills that create a relationship between problems

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

and students' cognitive structures; this is followed by an experimental analysis to verify the student's hypothesis.

Through STEM can prepare students to become more creative thinkers and problem solvers who have the skills and skills necessary to address problems and problems encountered on an everyday level in new and innovative ways (Siew, 2022). The EDP-STEM activity process is carried out in a way that allows students to be free when expressing their opinions and reflecting these opinions on their products. Therefore, each student is able to express his ideas and opinions (Sen et al., 2021). Supporting students in creating unique designs and products, these activities help them demonstrate creativity. Stem's integrated project-based learning model allows students to be more active and responsive in facing problems in the environment, such as and more creative. Through STEM-based projects based on learning models, students are able to define learning concepts and connect them with real life.

CONCLUSION

STEM-based PjBL is able to make it easier for students to define learning concepts and relate them to real life. STEM-based project-based learning models are able to exert influence to improve students' creative thinking skills. Through EDP being able to support students in creating unique designs and products, these activities help them demonstrate creativity. EDP approach, students are able to formulate concise ideas that are able to solve problems related to everyday life by using EDP steps in product manufacturing. EDP-STEM and its process flow of activities can help realize students' original thoughts and ideas. Discussion and brainstorming sessions are held to express students' opinions throughout the activity, which encourages students to express their own thoughts.

The EDP-STEM activity process is carried out in a way that allows students to be free when expressing their opinions and reflect these opinions on their products so that students' mathematical creative thinking skills can be optimally honed. Students are able to define basic problems (the ability to clarify the scope and context of problems) improved significantly after EDP-STEM-PjBL. They identify problem constraints, reconstruct problems, and summarize effective ideas. STEM-based PjBL through EDP is able to provide influence to improve students' creative thinking skills.

REFERENCES

Abidin, J., Rohaeti, E. E., & Afrilianto, M. (2018). Analisis Kemampuan Berfikir Kreatif Matematis Siswa Smp Kelas Viii Pada Materi Bangun Ruang. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *1*(4), 779. https://doi.org/10.22460/jpmi.v1i4.p779-784

Aldabbus, S. (2018). Project-Based Learning: Implementation & Challenges. *International Journal of Education, Learning and Development*, *6*(3), 71–79. www.eajournals.org

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Amala, M. A., & Ekawati, R. (2020). The Profile of Horizontal and Vertical Mathematization Process of Junior High School Student with High Mathematical Ability in Solving Contextual Problem of Fraction. *Jurnal Riset Pendidikan Dan Inovasi Pembelajaran Matematika (JRPIPM)*, *3*(2), 52. https://doi.org/10.26740/jrpipm.v3n2.p52-60

Brown, R. E., & Bogiages, C. A. (2019). Professional Development Through STEM Integration: How Early Career Math and Science Teachers Respond to Experiencing Integrated STEM Tasks. *International Journal of Science and Mathematics Education*, *17*(1), 111–128. https://doi.org/10.1007/s10763-017-9863-x

Chen, C. H., & Yang, Y. C. (2019). Revisiting the effects of project-based learning on students' academic achievement: A meta-analysis investigating moderators. *Educational Research Review*, *26*(October 2018), 71–81. https://doi.org/10.1016/j.edurev.2018.11.001

Daugherty, M. K., & Carter, V. (2018). *The Nature of Interdisciplinary STEM Education*. 159–171. https://doi.org/10.1007/978-3-319-44687-5_12

Edmunds, J., Arshavsky, N., Glennie, E., Charles, K., & Rice, O. (2017). The relationship between project-based learning and rigor in STEM-focused high schools. *Interdisciplinary Journal of Problem-Based Learning*, *11*(1), 1–6. https://doi.org/10.7771/1541-5015.1618

Fajrina, S., Lufri, L., & Ahda, Y. (2020). Science, technology, engineering, and mathematics (STEM) as a learning approach to improve 21st century skills: A review. *International Journal of Online and Biomedical Engineering*, *16*(7), 95–104. https://doi.org/10.3991/ijoe.v16i07.14101

Fong, C. J., & Kremer, K. P. (2020). An Expectancy-Value Approach to Math Underachievement: Examining High School Achievement, College Attendance, and STEM Interest. *Gifted Child Quarterly*, *64*(2), 67–84. https://doi.org/10.1177/0016986219890599

Glaze-Crampes, A. L. (2020). Leveraging communities of practice as professional learning communities in science, technology, engineering, math (STEM) education. *Education Sciences*, *10*(8), 1–8. https://doi.org/10.3390/educsci10080190

Husna, E. F., Adlim, M., Gani, A., Syukri, M., & Iqbal, M. (2020). Developing STEM-Based Student Worksheet to Improve Students' Creativity and Motivation of Learning Science. *Scientiae Educatia*, *9*(1), 57. https://doi.org/10.24235/sc.educatia.v9i1.6440

Jawad, L. F., Majeed, B. H., & Alrikabi, H. T. S. (2021). The Impact of Teaching by Using STEM Approach in The Development of Creative Thinking and Mathematical Achievement Among the Students of The Fourth Scientific Class. *International Journal of Interactive Mobile Technologies*, *15*(13), 172–188. https://doi.org/10.3991/ijim.v15i13.24185

Joklitschke, J., Rott, B., & Schindler, M. (2018). Theories About Mathematical Creati Vit Y in Contemporary Research : a Literature Review. *Proceedings of the 42nd Conference of the International Group for the Psychology of Mathematics Education*, *3*(July), 171–178.

Khalid, M., Saad, S., Abdul Hamid, S. R., Ridhuan Abdullah, M., Ibrahim, H., & Shahrill, M. (2020). Enhancing creativity and problem solving skills

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

through creative problem solving in teaching mathematics. *Creativity Studies*, *13*(2), 270–291. https://doi.org/10.3846/cs.2020.11027

Kong Suik. (2020). Pendekatan STEM dalam proses pengajaran dan pembelajaran : Sorotan Literatur Bersistematik (SLR) (STEM approaches in teaching and learning process : Systematic Literature Review (SLR)). *Pendidikan Sains & Matematik Malaysia*, *10*(2), 29–42.

Kotseva, I. (2019). Engineering Design-Based Learning in Integrative STEM Education. *Dl.Uctm.Edu*, *1*. https://dl.uctm.edu/see/node/jsee2019-1/9_SEE_19-11_p_62-67.pdf

Kovari, A., & Rajcsanyi-Molnar, M. (2020). Mathability and creative problem solving in the MaTech math competition. *Acta Polytechnica Hungarica*, *17*(2), 147–161. https://doi.org/10.12700/APH.17.2.2020.2.9

Lestari, T. P., & Sumarti, S. S. (2018). STEM-Based Project Based Learning Model to Increase Science Process and Creative Thinking Skills of 5th Grade. *Journal of Primary Education*, *7*(1), 18–24. https://doi.org/10.15294/jpe.v7i1.21382

Lin, K. Y., Wu, Y. T., Hsu, Y. T., & Williams, P. J. (2021). Effects of infusing the engineering design process into STEM project-based learning to develop preservice technology teachers' engineering design thinking. *International Journal of STEM Education*, *8*(1), 1–15. https://doi.org/10.1186/s40594-020-00258-9

Lin, L., Lee, T., & Snyder, L. A. (2018). Math self-efficacy and STEM intentions: A person-centered approach. *Frontiers in Psychology*, *9*(OCT), 1–13. https://doi.org/10.3389/fpsyg.2018.02033

Lou, S. J., Chou, Y. C., Shih, R. C., & Chung, C. C. (2017). A study of creativity in CaC 2 steamship-derived STEM project-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 2387–2404. https://doi.org/10.12973/EURASIA.2017.01231A

Marco-bujosa, L. (2021). *Prospective Secondary Math Teachers Encountering STEM in a Methods Course : When Math is More Than " Just Math " To cite this article : Prospective Secondary Math Teachers Encountering STEM in a Methods Course : When Math is More Than " Just Math ."*

Mathiphatikul, T., Bongkotphet, T., & Dangudom, K. (2019). Learning management through engineering design process based on STEM education for developing creative thinking in equilibrium topic for 10th grade students. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032015

Monica, Y., Rinaldi, A., & Rahmawati, N. D. (2021). *ANALISIS KEMAMPUAN BERPIKIR KREATIF MATEMATIS : DAMPAK MODEL OPEN ENDED DAN ADVERSITY QUOTIENT (AQ) Universitas Islam Negeri Raden Intan Lampung , Lampung , Indonesia Universitas Hasyim Asy ' ari , Jombang , Indonesia Institut Agama Islam Negeri Curup ,*. *10*(2), 550–562.

Nawang Sari, R., Tri Riya Anggraini, D., Komering Ulu, O., & PGRI Bandar Lampung, S. (2021). Pendekatan Steam Dalam Project Based Learning (PjBL) Mewujudkan Merdeka Belajar Untuk Peningkatan Hasil Belajar Siswa. *Jurnal Pengajaran Dan Riset*, *01*(02), 1.

Parno, Supriana, E., Yuliati, L., Widarti, A. N., Ali, M., & Azizah, U. (2019). The

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

influence of STEM-based 7E learning cycle on students critical and creative thinking skills in physics. *International Journal of Recent Technology and Engineering*, *8*(2 Special Issue 9), 761–769. https://doi.org/10.35940/ijrte.B1158.0982S919

Pratika S. (2018). Implementation of the Stem Learning To Improve the Creative Thinking Skills of High School Student in the Newton Law of Gravity Material. *Journal of Komodo Science Education*, *01*(01), 106–116. http:ejournal.stkipsantupaulus.ac.id/index.php/jkse

Putra, A., & Roza, M. (2020). Systematic literatur review: Adversity quotient dan self-efficacy dalam pembelajaran matematika. *At- Tarbawi*, *12*(2), 165–179. https://doi.org/10.32505/tarbawi.v12i2.2065

Rahmawati, L., & Juandi, D. (2022). *Pembelajaran matematika dengan pendekatan stem: systematic literature review*. *7*(1), 149–160.

Remijan, K. W. (2016). Project-based learning and design-focused projects to motivate secondary mathematics students. *Interdisciplinary Journal of Problem-Based Learning*, *11*(1). https://doi.org/10.7771/1541-5015.1520

Saironi, M., & Sukestiyarno, Y. (2017). Kemampuan Berpikir Kreatif Matematis Siswa dan Pembentukan Karakter Rasa Ingin Tahu Siswa pada Pembelajaran Open Ended Berbasis Etnomatematika. *Unnes Journal of Mathematics Educatio Research*, *6*(1), 76–88. http://journal.unnes.ac.id/sju/index.php/ujmer

Sen, C., Ay, Z. S., & Kiray, S. A. (2021). Computational thinking skills of gifted and talented students in integrated STEM activities based on the engineering design process: The case of robotics and 3D robot modeling. *Thinking Skills and Creativity*, *42*(August), 100931. https://doi.org/10.1016/j.tsc.2021.100931

Shahali, E. H. M., Halim, L., Rasul, M. S., Osman, K., & Zulkifeli, M. A. (2017). STEM learning through engineering design: Impact on middle secondary students' interest towards STEM. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(5), 1189–1211. https://doi.org/10.12973/eurasia.2017.00667a

Siew, N. M. (2017). Integrating STEM in an Engineering Design Process: The Learning Experience. *The Eurasia Proceedings of Educational & Social Sciences (EPESS)*, *6*(4), 128–141. http://library.uprm.edu:2404/ehost/detail/detail?vid=4&sid=2263ee5a-20f2-4b8c-af4e-6a8f58b789e9@sessionmgr101&hid=126&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=118132072&db=a9h

Siew, N. M. (2022). Exploring Students' Stem Imagination Process Through an Engineering Design Process. *International Journal of Teaching and Learning*, *01*, 1–18. https://doi.org/10.17501/26827034.2021.1101

Siswono, T. Y. E. (2015). *(Mari wes) Desain Tugas Untuk Mengidentifikasi Kemampuan Berpikir Kreatif Siswa Dalam Matematika*. 1–15. https://www.researchgate.net/publication/242735927_Desain_Tugas_untuk_Mengidentifikasi_kemampuan_berpikir_Kreatif_Siswa_dalam_Matematika%0A

Soumitra, D., Bruno, L., Rivera León, L., & Wunsch-Vincent, S. (2021). Global

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Innovation Index 2021: Tracking Innovation through the COVID-19 Crisis. In *World Intellectual Property Organization* (Issue 14th Edition). https://www.bloomberg.com/topics/global-innovation-index%0Ahttp://www.wipo.int/publications/ru/series/index.jsp?id=129

Sriraman, B. (2017). Mathematical creativity: psychology, progress and caveats. *ZDM - Mathematics Education*, *49*(7), 971–975. https://doi.org/10.1007/s11858-017-0886-0

Supandi, S., Suyitno, H., Sukestiyarno, Y. L., & Dwijanto, D. (2021). Learning barriers and student creativity in solving math problems. *Journal of Physics: Conference Series*, *1918*(4). https://doi.org/10.1088/1742-6596/1918/4/042088

Tubb, A. L., Cropley, D. H., Marrone, R. L., Patston, T., & Kaufman, J. C. (2020). The development of mathematical creativity across high school: Increasing, decreasing, or both? *Thinking Skills and Creativity*, *35*(February), 100634. https://doi.org/10.1016/j.tsc.2020.100634

Ummah, S. K., Inam, A., & Azmi, R. D. (2019). Creating manipulatives: Improving students' creativity through project-based learning. *Journal on Mathematics Education*, *10*(1), 93–102. https://doi.org/10.22342/jme.10.1.5093.93-102

Wang, M. Te, Ye, F., & Degol, J. L. (2017). Who Chooses STEM Careers? Using A Relative Cognitive Strength and Interest Model to Predict Careers in Science, Technology, Engineering, and Mathematics. *Journal of Youth and Adolescence*, *46*(8), 1805–1820. https://doi.org/10.1007/s10964-016-0618-8

Yousef Haik, T. S. (2011). Engineering Design Process. In *Gastronomía ecuatoriana y turismo local.* (Vol. 1, Issue 69).

Yustina, Syafii, W., & Vebrianto, R. (2020). The effects of blended learning and project-based learning on pre-service biology teachers' creative thinking skills through online learning in the COVID-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 408–420. https://doi.org/10.15294/jpii.v9i3.24706.