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The Implementation of Integrated Project-Based Learning Science Technology Engineering Mathematics on Creative Thinking Skills and Student Cognitive Learning Outcomes in Dynamic Fluid

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Abstract

This study aims to determine the effect of implementing STEM-integrated PJBL on students' creative thinking skills and cognitive learning outcomes. This research is quasi-experimental with a two-group pretest-posttest design. The research population is all grade 11th IPA SMAN 3 Bungo students, and the sample was determined by random sampling. Three projects conducted by the students were water pump free energy, fountain free energy, and air bubble generator. Two instruments of creative thinking test in essay form and multiple-choice for learning outcome test were used. The averages of pretest results of creative thinking and learning outcomes were 27.97 and 30.00 for the experiment class and 30.16 and 30.31 for the control, respectively. This shows that initial student ability in both the creative thinking skill and learning outcome of both types are level. STEM integrated PJBL was then used in the experiment class, and a conventional learning strategy was used for the control class. The average posttest results indicate that the student creative thinking skill of the STEM integrated PJBL class (82.81) is significantly higher than that of the control (36.72). Contrast with the posttest learning outcome showed no difference. These results show that the students actively engaged with the projects in the STEM integrated PJBL class improved their creative thinking skills significantly compared to the control class. This research's main finding is that implementing the STEM-integrated PJBL effectively enhances students' creative thinking skills. Manova analysis shows the students of the experiment class scored 76% in high and 63% in medium categories for both the creative thinking skills and learning outcome, respectively.

Keywords: cognitive learning outcome, creative thinking skills, project-based learning, STEM

INTRODUCTION

The industrial revolution 4.0 and the rapid evolution of technology impact the implementation of 21st Century education. Education requires 4C skills, including critical thinking and problem-solving, collaboration, creativity and innovation, and communication skills that prepare human resources (HR) to compete globally in the working world (Afandi et al. 2019). 4C skills in the student can enhance students so that they can meet the needs of graduates who can solve problems critically and provide creative solutions (Nakano & Wechsler 2018). In responding to this challenge, it is necessary to standardize the learning process that equips students with higher-order thinking skills (Sumarni & Kadarwati 2020).

Creative thinking is a skill that needs to be equipped and developed in students to improve their ability to solve problems creatively. Creative thinking can help students create new ideas and explore deeper fields of study (Fatmawati 2016). The impact is that students who are not equipped with 21st-century skills will experience confusion and uncertainty in facing global challenges (Afandi et al. 2019). According to Wang (2018), it is a significant challenge for the education system to develop skilled students, and education reform is needed. This is supported by an interview with a high school teacher in the Bungo Regency, where creative thinking skills are not required in the learning process, and this is a difficult challenge to create skilled students.

The low creative thinking skills of students also have an impact on students' physics learning outcomes. This is supported by previous research, which states that students find it challenging to understand the material because they do not experience what they are learning for themselves (Fitriani et al. 2016). According to the teacher in physics studies, the factors of interest and motivation of students in learning physics also affect the less than optimal student learning outcomes. In addition, students also have difficulty connecting the interrelationships of various disciplines with the physics concepts they are studying.

Real-life linkages are expected to make learning more meaningful and accessible for students to understand physics concepts and their real-world applications. Besides closely related to real life, physics learning is also interrelated with several disciplines. Therefore, education should be able to integrate several fields so that students have multidimensional abilities to be used in modern life, namely by implementing the Science, Technology, Engineering, and Mathematics (STEM) approach (Nugroho et al. 2019).

STEM education is an approach that integrates multidisciplinary knowledge into the learning process by linking academic concepts and real-world lessons experienced in schools, communities, work, and global companies (Akaygun & Tutak 2016; Evik & Zgunay 2018). This is linear with predictions that in the next few decades, an increase in employment in the STEM sector will occur (Mutakinati et al. 2018). So the STEM approach needs to be equipped and developed for students in the learning process at school in response to the challenges of future needs. So that when it is possible for students not to work based on educational backgrounds, STEM contributes to bridging the gap between education and the workplace that requires 21st-century skills (Hasanah & Tsutaoka 2019; Mutakinati et al. 2018).

The STEM approach will make learning meaningful if integrated with project-based learning (PJBL). According to Afriana et al. (2016), the PJBL model is a learning model following the 2013 Revised Curriculum reference with a student-centered scientific approach, providing a meaningful learning experience by constructing concepts through the product. PJBL-STEM integration will explore students' skills to solve problems creatively through projects, which will arouse students' curiosity to engage in investigations (Han et al. 2016).

Previous research has been conducted regarding implementing PJBL-STEM, improving students' critical and creative thinking skills (Mutakinati et al. 2018; Sumarni & Kadarwati 2020). While in a study conducted by Afriana et al. (2016) shows that all students are enthusiastic about PJBL-STEM learning, have an impressive experience, and have increased motivation and interest in education. Implementing PJBL-STEM in schools can reduce achievement gaps, benefit low-achieving students, and help students solve math problems (Han et al. 2014). This is also supported by the research of Purwaningsih et al. (2020). Implementing PJBL-STEM improves students' problem-solving skills in impulse and momentum material. It can improve student learning outcomes, cognitive and psychomotor, and student creativity in solving problems (Meita et al. 2018).

Based on the explanation of the background of the problem and previous research, research was conducted on: "Implementation of Integrated Project-Based Learning Science Technology Engineering Mathematics on Creative Thinking Skills and Student Cognitive Learning Outcomes". This research was conducted at SMA Negeri 3 Bungo on Dynamic Fluids. This approach is never used before, and the results of this study could be used as a model of meaningful learning experiences. In this study, the students in the experiment class completed three projects, while the control class was done with a conventional approach.

METHODS

Research Design

This study adopted a quasi-experimental study with a two-group pretest-posttest design. This design was chosen to see the application of STEM-integrated PJBL in one group and the difference between conventional learning based on pretest and posttest. The researcher gave a pretest to see the initial ability of the two classes on creative thinking skills and cognitive learning outcomes. Furthermore, STEM-integrated PJBL treatment will be provided in the experimental class and conventional learning in the control class. After treatment, a posttest will be conducted to see creative thinking skills and student cognitive learning outcomes. The research design is shown in TABLE 1.

TABLE 1. Pretest-posttest group research design

Group	Pretest	Treatment	Posttest
Experiment	O	X	O
Control	O	-	O

Information: X = Use of project-based learning integrated science technology engineering mathematics
O = Output test

The pretest data will be analyzed using an independent sample t-test. In contrast, the posttest data will be analyzed using a multivariate analysis of variance (manova) with the help of SPSS software. Next will be the N-gain test to improve students' creative thinking skills and cognitive learning outcomes.

Participants

This research was conducted at SMA Negeri 3 Bungo in grade 11th IPA. The research population consisted of 5 classes totaling 156 students. The five classes were randomly selected to be taken as a research sample of 2 categories. The samples were divided into two groups: the experimental group applying STEM-integrated PJBL and the control group with conventional learning, each totaling 32 students. Students' activities in the practical class will be doing projects in the control class by teaching lectures and practicing Dynamic Fluids. Students will be given a test of creative thinking skills and learning outcomes before and after the treatment. The research sample did not study fluid dynamics before administering the pretest.

Projects-Based Learning Integrated Science Technology Engineering Mathematics

The STEM-integrated PJBL is a student-centered learning model and provides a meaningful learning experience for students whose process follows trends in the era of globalization (Afriana et al. 2016). The goal, according to Tseng (2013), Through the integrated PJBL process, STEM to help students in solve everyday life problems and support future careers. This is also relevant to the skills required in 21st-century education, namely 6C, one of which is creative thinking skills. Through the integrated PJBL STEM, students will build creative thinking skills in project work. In this study, students in the experimental class will be divided into three groups. Each group works on three project items, which will be combined into a free-energy aquarium. The three projects are water pump-free energy, fountain-free energy, and water bubble-free energy. The project description can be seen in TABLE 2.

TABLE 2. Dynamic fluids project description

Projects	Topics	Images
Water pump free energy	Bernoulli's principle	
Fountain free energy	Torricelli's Theorem	
Air bubble generator free energy	Pressure on venturi meter	

The student activities in the project are planning, preparing tools and materials, discussing and carrying out project creation procedures, piloting the project, analyzing the project, and presenting the project results in a video presentation. Students will integrate science, technology, engineering, and mathematics into project work. This will make students accustomed to connecting multi-disciplines in dealing with everyday problems. Through the project, students will be prepared to become individuals who are responsive to change and have 6C skills, one of which is creative thinking. In addition, working in groups will help students collaborate to produce the best projects.

Instrument and Procedure

The instruments used in the research are creative thinking skills tests and cognitive learning outcomes tests. The innovative thinking skill test is an essay with five items, while the cognitive learning outcome test is in the form of multiple-choice and consists of 10 items. Before giving treatment, students will be given a pretest of creative thinking skills and cognitive learning outcomes to determine students initial abilities. After giving PJBL STEM-integrated treatment in the experimental class and conventional learning in the control class, a posttest will be conducted to test creative thinking skills and students' cognitive learning outcomes. Creative thinking skills are measured based on fluency, flexibility, originality, and elaboration indicators. Grids of the innovative thinking test and cognitive learning outcome are presented in TABLE 3 and TABLE 4.

TABLE 3. Grid of test instruments for creative thinking skill

Indicators	Description	Subtopic	Items
Fluency	Generating ideas or alternative solutions for a problem	Bernoulli's principles	3
Flexibility	Generating several ideas with many possible approaches	Bernoulli's principles & continuity	2 & 4
Originality	Generating new ideas that were never thought of before/modifying ideas	Torricelli's theorem	5
Elaboration	Generating answers in detail	Pressure on venturi meter	1

TABLE 4. Grid of test instruments for cognitive learning outcomes

Bloom's taxonomy	Subtopic	Items
Understanding (C2)	Pressure, characteristics of fluid, continuity, flow rate,	1, 2, 5 & 10
Applying (C3)	Continuity	3, 6 & 8
Analyzing (C4)	Bernoulli’s principle, continuity & Torricelli's theorem	4, 7, & 9

RESULTS AND DISCUSSION

Results

The data collection tool obtained the average pretest and posttest values of creative thinking skills and students' cognitive learning outcomes. The results showed that the average pretest scores for creative thinking skills and students' cognitive learning outcomes in both classes were the same. This indicates that students have the same initial ability to think creatively and learning outcomes for dynamic fluid materials. However, after the treatment, there was a significant difference in students' creative thinking skills. The improvement of students' creative thinking skills in the experimental class is also in the high category, 76%.

Meanwhile, there was no significant difference in the cognitive learning outcomes of the two types. Both classes experiment and control each experienced increased cognitive learning outcomes in the medium category. The average pretest dan posttest can show in Table 5.

TABLE 5. Descriptive statistics for creative thinking skills and cognitive learning outcome.

Variable	Group	Pretest		Posttest		N-gain (%)	Criteria
		Mean	SD	Mean	SD		
Creative thinking skills	Experiments	27.97	13.61	82.81	9.99	76	High
	Control	30.16	12.34	36.72	8.09	7	Low
Cognitive learning outcome	Experiments	30.00	13.44	73.13	16.93	63	Medium
	Control	30.31	16.93	72.50	13.67	61	Medium

The increase in N-gain for each indicator of creative thinking skills is also presented in TABLE 6. The highest average increase in N-gain obtained by the experimental group is on the fluency indicator of 80% and the lowest on the originality indicator of 70%. The increase in both is categorized as high. While the rise in N-gain on average, the highest creative thinking skill indicator in the control class is the elaboration indicator, and the lowest is originality. Both are in a common category, with 20% elaboration and 4% originality.

TABLE 6. Improvement for each indicator of creative thinking skills

Indicator	**PJBL integrated STEM**		**N-gain (%)**	**Criteria**	**Conventional learning**		**N-gain (%)**	**Criteria**
	Pretes t	**Posttest**			**Pretest**	**Posttest**		
Fluency	7.34	17.50	80	High	8.28	8.75	4	Low
Flexibility	5.70	16.40	75	High	6.17	7.42	9	Low
Originality	4.68	15.46	70	High	5.78	5.93	1	Low
Elaboration	4.53	15.93	74	High	3.75	7.18	21	Low

The increase in student learning outcomes for each cognitive level is presented in TABLE 7. The average increase in N-gain learning outcomes is highest in the experimental class at level C2 and the lowest at C3. Meanwhile, in the control class, the rise in N-gain learning outcomes was highest at the C3 level and the weakest at C4. The increase in N-gain at each cognitive level was in the medium category.

TABLE 7. Improvement for each Bloom's Taxonomy of cognitive learning outcome

Bloom's Taxonomy	PJBL integrated STEM		N-gain (%)	Criteria	Conventional learning		N-gain (%)	Criteria
	Pretest	Posttest			Pretest	Posttest		
Understanding (C2)	3.28	7.75	66	Medium	3.12	7.12	58	Medium
Applying (C3)	3.43	6.87	52	Medium	3.43	7.71	66	Medium
Analyzing (C4)	2.18	7.18	64	Medium	2.59	6.78	56	Medium

Data Analysis

The data analyzed in this study were in the form of test data for creative thinking skills and students' cognitive learning outcomes. The cognitive learning outcomes will analyze the pretest data to test the students' initial abilities before being given treatment. Then the posttest data will be analyzed to see the increase in creative thinking and student learning outcomes after treatment. The researcher analyzed quantitative data from the pretest and posttest used to measure creative thinking skills and students' cognitive learning outcomes to test the effect of treatment on each group. To analyze the data using multivariate analysis of variance (manova). Manova prerequisite tests are covariate normality test, data homogeneity test, and Box's M test (Putich & Stevens 2016). Data analysis was assisted by IBM SPSS 19 for Windows software with a significant level of $p < 0.05$. The percentage increase in creative thinking skills and cognitive learning outcomes were analyzed using a normalized gain average (N-gain) (Bao 2006):

$$G = \frac{posttest\ average\ -\ pretest\ average}{maximum\ score\ -\ pretest\ average} \tag{1}$$

The value of N-gain > 0.7 is categorized as high, 0.3 > (N-gain) < 0.7 is categorized as medium and N-gain < 0.3 is categorized as low

Independent Sample T-Test

An independent sample t-test will analyze pretest data of creative thinking skills and cognitive learning outcomes. With the condition that the data are typically distributed and come from homogeneous variants. Results of data analysis are presented in TABLE 8. The prerequisite tests for the independent sample t-test are the normality test and the homogeneity test. Normality test using Kolmogorov-Smirnov and homogeneity test using Levene's test. For creative thinking skills, pretest data were normally distributed with a significance value of 0.069 > 0.05 in the experimental class and 0.063 > 0.05 in the control class. Furthermore, it will be continued with the homogeneity test obtained a significance value of 0.212 > 0.05, then the data comes from the same variance. After the conditions for normality and homogeneity are met, it is continued with the independent sample t-test. The result of sig. (2-tailed) 0.503 > 0.05, it can be interpreted that there is no significant difference in students' creative thinking skills in the experimental and control classes

TABLE 8. Output independent sample t-test for creative thinking skills and cognitive learning outcomes

Data	Kolmogorov-Smirnov		Levene's test		Sig. (2-tailed)	
	Creative thinking	Learning outcomes	Creative thinking	Learning outcomes	Creative thinking	Learning outcomes
Pretest	0.069	0.078	0.212	0.673	0.503	0.930
	0.063	0.073				
Posttest	0.068	0.083	0.551	0.256	0.000	0.871
	0.078	0.080				

The independent sample t-test on creative thinking is also relevant to students' cognitive learning outcomes. In the normality test of the pretest data for cognitive learning outcomes, a significance value of 0.078 > 0.05 was obtained in the experimental class and 0.073 > 0.05 in the control class, so it was decided that the data was normally distributed. The homogeneity test results obtained a significance value of 0.673 > 0.05, so the data came from the same variance. The results obtained sig.(2-tailed) for the independent sample t-test 0.930 > 0.05. Based on the data, it can be interpreted that there is no significant difference in students' cognitive learning outcomes.

Multivariate Analysis of Variance (MANOVA)

Manova test is used to test whether there is a difference in the mean of two dependent variables simultaneously based on groups of nonmetric independent variables while the independent variables are metric. The results of the prerequisite test for normality and homogeneity of the posttest data can be seen in TABLE 8. Based on TABLE 8. The data meet the requirements for normality and homogeneity; then, it can be continued to the Box's M test. . The results of the manova analysis can be seen in TABLE 9.

TABLE 9. Output multivariate analysis of variance

Sig Box's M	Test of between-subject effect		Multivariate Test		
	Creative thinking skills	Cognitive learning outcomes	Class	Value	Sig
0.355	0.000	0.871	Pillai’s Trace	0.869	0.000
			Wilks’ Lambda	0.131	0.000
			Hotelling’s Trace	6.630	0.000
			Roy's Largest Root	6.630	0.000

Next is the multicollinearity test, which aims at the two dependent variables, creative thinking skills, and cognitive learning outcomes. The aim is to test the linearity of the two dependent variables. So if it is linear, it will try the same two things. Based on the test of the between-subject effect, hypothesis testing can be conducted, for the first is the dependent variable on creative thinking skills. Hypothesis 1 test is obtained sig value of 0.000, which means < 0.05, it can be decided that H_0 is rejected and Ha is accepted. So the conclusion for Hypothesis 1 is that there is a significant difference between the STEM-integrated Project Based Learning (PJBL) model and conventional learning on students' creative thinking skills on the dynamic fluid subject matter at SMA Negeri 3 Bungo Academic Year 2021-2022.

Hypothesis 2 was tested based on the test of the between-subject effect, the sig value is 0.871, which means > 0.05, so it can be decided that H0 is accepted and Ha is rejected. So the conclusion for Hypothesis 2 is that there is no significant difference between the STEM integrated Project Based Learning (PJBL) model and conventional learning on cognitive learning outcomes on the dynamic fluid subject matter at SMA Negeri 3 Bungo Academic Year 2021-2022. Furthermore, hypothesis 3 is viewed from the fourth row of the multivariate test class with a sig value of 0.000 < 0.05. It was decided that H0 was rejected, and Ha was accepted. So the conclusion for Hypothesis 3 is that there is a simultaneous difference in the STEM-integrated Project Based Learning (PJBL) model on creative thinking skills and student learning outcomes on the subject matter of dynamic fluids at SMA Negeri 3 Bungo Academic Year 2021-2022.

Discussion

The implementation of learning in the experimental class has been formed in three groups with two groups of 11 students and one group of 10 students. From the research that has been done, creative thinking skills are also influenced by collaborative project work (Brophy 2006; Simanjuntak 2021). STEM-integrated project-based learning has been previously applied to static fluid learning. The goal is that students already know the stages of STEM-integrated PJBL so that students are not confused when applied to dynamic fluid material. STEM-integrated PJBL on static fluid materials is applied to all XI IPA classes at 3rd State Senior High School of Bung. This is because researchers have not determined the sample used in the study.

The first meeting in the experimental class was giving a pretest to determine the student's initial abilities. The subject teacher coordinates this meeting, and the researcher acts as an observer when students do the pretest. At the time of the pretest, many students were confused because they were not familiar with creative thinking skills, which are closely applied in everyday life. The researcher advises students to answer questions based on what students know without seeking information from other sources.

In the second meeting, the teacher explained the project the students would work on in groups. The researcher distributed the free energy water pump project plan sheets to each group. And students in groups began to discuss the project design done with the information that had been dug up. Students start to schedule project creation from planning to project presentation. Students begin to design a project design that will be made and take the tools and materials that have been provided by the researcher and some materials prepared by the students. Some students make videos of the project creation process for those who are part of the project-making report. The researcher observed each student group activity, provided suggestions for students who had difficulty, and asked questions about the project.

At the third meeting, the student activities were making a free energy fountain project. The project process was the same as the free energy water pump project. In working on this project, one group of students found it difficult because the project had been made not to work. Teachers and researchers help groups of students to find out why the project they are creating does not work by asking the concept of Torricelli's Theorem so that it leads students to find the cause of the project not working and find a solution so that the project can work.

At the fourth meeting, students worked on a free energy air bubble generator project with the same stages as the previous two projects. The three groups succeeded in completing the project despite experiencing several failures. Through the causes of projects that do not work, students better understand the concepts of fluid dynamics in the tasks they are performing. In addition, student activities at this meeting presented projects made in the form of videos. Students work together in editing videos for making three aquarium devices and making project presentation videos.

At the fifth meeting, the researchers gave a posttest to students to measure creative thinking skills and student learning outcomes. At the time of the posttest, students no longer experienced confusion. This is because the posttest questions can be done because through the STEM-integrated PJBL process, students share their learning experiences and construct their knowledge about dynamic fluids. Through doing projects, students' creative thinking skills also develop.

This development can be seen in the significant difference in the results of students' creative thinking skills. Classes that apply STEM-integrated PJBL learning have higher creative thinking skills than classes that use conventional learning methods. This result follows previous research that has been done. STEM-integrated PJBL develops students' creative thinking skills (Chantala et al. 2017; Sumarni & Kadarwati 2020; Widarti et al. 2020). Through STEM, PJBL will affect students' thinking, activities, and learning experiences, which will develop creativity (Mukaromah 2020; Yustina et al. 2020) and also improve communication skills in students (Asih & Ellianawati 2019).

Creative thinking skills are essential in education and prepare students for the real world of professional work (Ridlo 2020). Students are expected to synergize between knowledge and student application of content and think creatively to provide solutions in dealing with a situation from a different perspective (Hardiman 2010; Rotherham & Willingham 2009; Setya Putri et al. 2017). Of the five indicators of creative thinking skills observed, the experimental class was superior to each hand compared to the control class.

The high category is the improvement of students' creative thinking skills with STEM-integrated PJBL in the experimental class. This is shown in FIGURE 1. through the average normalized gain test, the practical class increases by 76% and the control by 7%. This is also supported by previous research that through STEM integrated PJBL, the improvement of students' creative thinking skills is in the high and medium categories (Sumarni & Kadarwati 2020). In the experimental class, students who get an increase in the medium type are 25%, and in the high category, 75%. While in the control class, 7% of students' problem-solving skills are of a low variety. Through this process, students experience the learning stages themselves to develop creative thinking skills. Improving creative thinking skills through this process indicates that STEM-integrated PJBL facilitates students to enhance their creative thinking skills (Annisa et al. 2018; Saefullah et al. 2021; Sumarni & Kadarwati 2020; Syaiful et al. 2020).

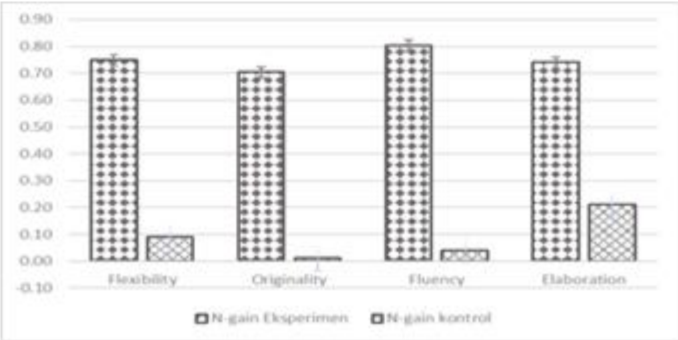

FIGURE 1. Improvement for each indicator of creative thinking skills

Students in the experimental class obtained the highest score than the fluency indicator, based on the results of the normalized gain calculation. The improvement of students' creative thinking skills on this indicator is in the high category. These results are obtained from how students analyze and interpret solutions based on mathematical equations from the data obtained. This indicator is due to the ability of students to answer questions in a coherent, systematic manner and perform calculations correctly. This finding is also supported by Han et al. (2016) that PJBL integrated STEM learning approach is the right way to improve students' math scores. Meanwhile, the improvement of problem-solving skills is low in the control class. This is because students are not faced with working on projects that help students explore creative thinking skills (Syaiful et al. 2020).

Originality indicators in both classes show the lowest increase in N-gain. The experimental type is in the medium category, and the control class is in a subordinate variety. Most students have difficulty providing original solutions to problems. This is because students get the dynamic fluid concept based on rote, so students are less innovative and imaginative in creating new ideas. Only a few students answered with new ideas and could describe them well. The resulting creative ideas tend not to be unique but to modify existing ideas.

The increase in N-gain on the flexibility and elaboration indicators is not much different. But the experimental class is in the high category while the control class is in the standard type. Previous research shows that providing challenges at each stage of STEM-integrated PJBL can motivate students to find information that supports the material being taught that is relevant to real-life (Sumarni & Kadarwati 2020). Students demonstrate that students are capable of flexibility and elaboration skills by thinking flexibly and broadly in giving arguments to the problems contained in the project plan sheet. The posttest results show that students can demonstrate the relevance of fundamental issues and solutions to the concept of fluid dynamics. In this case, students can also understand the relationship between the problem and several other disciplines.

In the projects that students work on, they also use their connection with the disciplines of science, technology, engineering, mathematics, and even the arts. The results of this study are relevant to previous research that real-life-based learning activities can help students realize the importance of theory and science (Account 2017; Chonkaew et al. 2016). The application of STEM-integrated PJBL can help students develop flexibility in thinking so. This proves that students' creative thinking activities and abilities will be higher when students conduct discussions or experiments in groups compared to receiving information/concepts from the teacher (Sumarni 2020).

Although both classes experienced an increase in learning outcomes after being given treatment, the average score in the experimental class was superior to the control class. This shows that improvement through the STEM-integrated PJBL process is an appropriate and exciting method for students. So that students more easily understand a concept through direct experience in learning. STEM-integrated PJBL also helps students think reflectively, and the results of this study are also supported by previous research that STEM-integrated PJBL influences students' cognitive learning outcomes (Retno 2019; Ergul 2013). Meanwhile, according to Fini (2018), project-based learning contributes to improving the dimensions of student learning outcomes.

Applying conventional learning is also not wrong in the classroom if it is done correctly and focused. This is indicated by the influence of traditional education on better student learning outcomes based on posttest scores. In this study, applying STEM-integrated PJBL and conventional learning affected students' cognitive learning outcomes. It's just that in traditional education, teachers tend to be more dominant than students. Meanwhile, 21st-century learning requires students to have skills that will be equipped to face global challenges (Afandi et al. 2019; Akaygun & Aslan-Tutak 2016; Honeck 2016; Hussin 2019). Of course, conventional learning is less effective if applied at this time if the STEM-integrated PJBL method can develop 21st-century skills in addition to student cognitive learning outcomes.

Through STEM-integrated PJBL, students have both educational and non-academic benefits. One of the educational benefits that students get is learning to analyze data and reflect the findings of concepts from project work. Meanwhile, for non-academic benefits, students can manage and work in teams, take responsibility, manage time, be consistent, exchange information, and convey project results through communication. With these benefits, it will undoubtedly be a valuable lesson for students in preparing students for the real world of work.

Although conventional learning and STEM-integrated PJBL can improve student learning outcomes, they still have a different essence to the process. STEM-integrated PJBL is sustainable and constructive or design-oriented. It involves lessons in constructive inquiry in design, decision making, problem finding, problem-solving, knowledge discovery, knowledge transformation, and knowledge construction (Parwati 2019; Mergendoler 2007). While conventional learning is learning that is often done by teachers and tends to be teacher-centered. Traditional learning activities based on behavioristic theory are dominated by teachers (Parwati 2019). If it is related to the implementation, holistic information about students' abilities cannot be known comprehensively. How the students are in each phase of learning is also unknown. As a result, feedback is minimal. So it is essential to implement learning such as STEM integrated PJBL that can build skills and learning outcomes. As for the future, it is also possible to apply other learning models such as in other studies learning dynamic physics can be carried out in a fun way by using a problem-based learning model (Nissa & Dheanti 2021).

CONCLUSION

This study shows that implementation of the STEM-integrated PJBL improves students' creative thinking skills significantly. However, the student's cognitive learning in both classes (the STEM-integrated PJBL and conventional type) shows no difference in the average learning outcomes. The improvements in the cognitive learning outcomes in both the experiment class and control class are 63% and 61%, respectively, and both are medium category. In addition, there are also simultaneous differences in STEM-integrated PJBL on creative thinking skills and students' cognitive learning outcomes on dynamic fluid material. The results of this study show that selecting and determining teaching approaches relevant to the challenges of 21st-century education is essential. Although through conventional learning, students also have increased cognitive learning outcomes, the teacher's process of acquiring knowledge is dominant, so students' creative thinking skills are not constructed. Physics educators can implement STEM-integrated PJBL on other materials to build and develop students' creative thinking skills. Educators need to pay attention to and finalize the planning of the project to be carried out and its relevance to STEM. Through the process of creative thinking, students will construct their knowledge through learning experiences so that students have increased cognitive learning outcomes. Therefore, STEM-integrated PJBL is more suitable to be applied in responding to the needs of the global challenges of 21st-century education.

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