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PROJECT BASED LEARNING (PJBL) MODEL WITH STEM APPROACH ON STUDENTS' CONCEPTUAL UNDERSTANDING AND CREATIVITY

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ABSTRACT

The starting point of this research is the absence of understanding of students' conceptions of the human movement system material, as well as students' unformed creativity. This study aims to analyze the effect of the STEM-approach PjBL model on students' conceptual understanding and creativity. This research was quantitative research with a quasi-experimental method with a post-test-only control design type. The sampling used a purposive sampling technique. The instruments used were concept comprehension tests, syntax implementation observation sheets, and creativity questionnaire sheets. The paired sample t-test was used to analyze the data. Based on data analysis, the average post-test results for the experimental and control classes are 83.44 and 79.14, respectively. The data analysis of the student creativity questionnaire results suggest that 19 students are quite creative. The paired t-test result for students' concept understanding is 0.002, indicating that the research hypothesis is accepted, while the result for creativity is 0.64. With moderate criteria, the PjBL model with the STEM approach effects students' conceptual understanding and creativity.

Keywords: concept understanding; creativity; PjBL; STEM

INTRODUCTION

Education is a process of both formal and informal interactions between educators and students. In formal education, learning plays a significant role in shaping students to become talented human beings, using thinking skills in terms of learning activities and applying them in life (Bernard et al., 2018). A high-quality learning process can result in high-quality student learning results (Nasution, 2017). The teaching and learning process can be successful if the teacher can appropriately regulate the learning process (Mansir, 2020).

Ideal learning is learning that can encourage and foster student creativity. Overall, it can make students more active so that learning objectives will be easily achieved (Jamilah, 2020; Karjo et al., 2021). The implementation of learning, primarily when online, presents its own problems, such as teachers having difficulty providing understanding (Yohannes, 2021), many perceptions and perspectives that arise from students (Ardiyanti et al., 2020), and lack of achievement of learning objectives (Andriani et al., 2021). To achieve this ideal learning, skills must be developed in the educational process, including conceptual understanding and creativity.

Understanding concepts is vital because students must understand the significance of what they are studying. Students can solve difficulties in a variety of ways in addition to fulfilling learning objectives (Pitaloka, 2012; Stovner & Klette, 2022). Teachers must know the extent to which students' conceptual understanding of the

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materials is provided to be able to innovate learning (Ummaeroh, 2019). Teachers should apply an approach that can construct concepts from the abstract to those that are easier to understand (Sagala, 2017).

Building conceptual understanding that leads to knowledge of science can be the beginning of student creativity (Rasul et al., 2018). Learning and creativity are interrelated and have an enormous social impact (Willerson & Mullet, 2017). If students have high creativity in learning activities, these students will have a more significant curiosity to understand all the problems in the lesson (Afghani, 2021).

Human movement system material is abstract biology material with extensive discussion and many terms memorized and is considered one of the materials that students view as complicated during learning (Pradana, 2017). Students need to help understand material on human movement systems because the material contains processes in the body that cannot be seen easily, and the level of student activity needs to be improved in the learning process. Teachers must encourage students to participate actively in the learning process. Applying a learning approach that demands students to be active and creative is one strategy to engage students in learning (Sari, 2018; Puspitarini & Hanif, 2019).

Observations in numerous schools in Kebumen Regency all show that students' creativity and conceptual understanding might be improved. The exam results of students with an average of 67.5 who have not yet met the minimum mastery criteria demonstrate this. This is consistent with Sumarni et al. (2019), who demonstrate that students have not succeeded in understanding topics and lack the ability to become active, creative thinkers and problem solvers.

The growth of student creativity relies on the teacher's understanding of how creativity develops (Herak & Lamanepa, 2019). As many as 65% of teachers still use traditional learning, in which the learning process primarily teaches convergent thinking processes, such that when faced with a problem, students struggle to solve it creatively (Sari, 2015; Kusumawati, 2018). Teachers must employ a learning strategy that fosters students' creative thinking. The STEM learning method using the PjBL model is one learning technique that may be utilized to educate creativity skills (Yuni & Bukit, 2021).

Problem-based learning and case studies are currently in use since they are tied to the Merdeka Curriculum's output, one of which is project-based learning (PjBL). PjBL is an inquiry-based educational technique in which students participate in knowledge production by being assigned relevant tasks and required to develop real-world products (Brundiers & Wiek, 2013; Krajcik & Shin, 2014; Prajoko, 2023). PjBL's advantages include prompting questions that begin with a problem, concentrating on learning objectives, student participation in learning activities, student cooperation, use of technology, and generating an authentic product (Krajcik & Shin, 2014). Among these benefits, the generation of products to solve an authentic problem stands out PjBL from other student-centered pedagogies such as problem-based learning (Aksela & Haatainen, 2019; Jalinus et al., 2019; Hidayah et al., 2021; Prajoko et al., 2023). Another advantage of PjBL is its high potential for making learning experiences more engaging and meaningful for students for them to grasp topics (Shpeizer, 2019).

STEM (Science, Technology, Engineering, and Mathematics) education is in desperate need of improvement (Shaer et al., 2019). STEM is a National Science Foundation initiative (Permanasari, 2016). STEM presents many pedagogical techniques, such as existing methodologies, models, and frameworks for incorporating STEM in the classroom (Park & Cho, 2022). STEM (science, technology, engineering, and mathematics) is an educational paradigm in which science, technology, engineering, and mathematics are incorporated into the educational process to tackle real-world problems (Davidi et al., 2021). The STEAM approach can hone and develop students' skills to provide ideas to become more creative (Hadinugrahaningsih et al., 2017).

Students are urged to participate in meaningful learning by comprehending a topic and exploring it through a project activity using the STEM-PjBL approach (Furi et al., 2018; Thahir et al., 2020). This encourages students to think critically, creatively, and analytically while also developing higher-order thinking skills. STEM-integrated PjBL, according to the findings of Tseng et al. (2013) research, can boost students' concept understanding and learning interest, and learning becomes more meaningful, assisting students in solving real-life problems and supporting future jobs. Furthermore, STEM in PjBL challenges and inspires students by teaching them to think critically, analyze, and strengthen higher-order thinking skills (Capraro & Morgan, 2013; Cheng & So, 2020; Sirajudin & Suratno, 2021).

The objective of this study is to investigate the effect of the STEM-approach PjBL learning model on students' conceptual understanding and creativity in human movement system material. The effect of PjBL learning on conceptual understanding and creativity in students will be determined by examining the influence of PjBL learning utilizing the STEM approach.

STEM-based PjBL is a crucial subject that has received little attention, thus this study will assist in expanding educational libraries and broaden views for implementing current teaching methodologies (Dorofeeva et al., 2020; Pugh, 2020). Research on integrating STEM-PjBL to understand concepts and think creatively in biology learning is rarely carried out (Fitriyah & Ramadani, 2021). By applying this learning, students can explore their respective scientific, technological, and creative literacy (Mayasari et al., 2014).

METHODS

This research was quantitative research with a quasi-design experiment of post-test-only control type (Hastjarjo, 2019). In education, quasi-experimental designs are considered an alternative to actual experimental designs due to random and manipulation conditions (McMillan & Schumacher, 2010; Fraenkel et al., 2011; Bi et al., 2020).

This method was utilized to investigate the effect of the treatment on the experimental class utilizing the PjBL model STEM approach. The control group utilized a traditional learning model.

Experimental	X	O_1
Control	-	O_2

Description
O_1: Post-test of the experimental class; O_2: Post-test of the control class; X: Treatment in the form of applying the PjBL model with the STEM approach. While the control class used conventional learning with a teacher-centred learning approach.

In this study, the samples taken consisted of 2 classes, which were determined utilizing purposive sampling (Creswell & Poth, 2016), considering the average final semester biology exam scores for each class. Based on the homogeneity test results, the samples used were class XI MIPA 1 as the experimental class and class XI MIPA 2 as the control class, each consisting of 36 students.

The instruments used were a learning syllabus, lesson plans, observation sheets to observe the implementation of learning syntax, instrument expert validation sheets, concept understanding test sheets, and creativity questionnaire sheets containing questions about what students feel or do in the learning process.

Tests, questionnaires, and observation were data collection techniques used. The test was conducted to determine the level of students' concept understanding. The questionnaire was conducted to determine student creativity regarding the learning process using the PjBL model with a STEM approach. The indicators of creativity included fluency, flexibility, originality, and elaboration. Then, the observation was carried out directly at SMA N 1 Sumpiuh. The results of measuring creativity are then classified according to the following criteria in Table 1.

Table 1. The Criteria of Creativity (C)

Score of creativity	Criteria
$0.86<C\leq1.00$	very creative
$0.70<C\leq0.86$	creative
$0.60<C\leq0.70$	moderate
$0.40<C\leq0.60$	less
$C\leq0.40$	poor

Data analysis carried out in this study was analysis of content validity and item validity for the test questions and analysis of student creativity questionnaires by calculating the percentage in each aspect.

RESULTS AND DISCUSSION

Based on observations of the implementation of the learning syntax, the researcher has carried out a series of learning in general. Table 2 shows the outcomes of the deployment of the learning syntax. The post-test results for the experimental and control groups are shown in Table 2. Figure 1 shows that the average post-test result in the experimental group is 83.44, with a minimum of 70 and a maximum of 93. The average post-test result in the control group was 79.14, with a minimum score of 70 and a maximum score of 90. The average difference in concept understanding between the experimental and control groups indicates the influence of employing the PjBL model combined with the STEM approach on students' concept understanding.

Table 2. Implementation of Learning Syntax

No.	Learning Steps	M1	M2	M3	Student outcome
1.	Determine Fundamental Questions	87,5%	-	-	Students understand the project problem
2.	Design Project Planning	100%	-	-	Project design
3.	Arrange Schedule	100%	-	-	Project schedule
4.	Monitor Student and Project Progress	-	100%	-	Mind map
5.	Test Results	-	-	100%	Concept understanding
6.	Evaluate Experience	-	-	83,3%	Student reflection
	Average Per Meeting	95,8%	100%	91,7%	
	Overall Average		95,8%		
	Criteria		Very good		

Description:
M: Meeting
The learning syntax is implemented at 95.8%, included in the very good criteria.

Students' creativity is assessed based on the manufacturing processing map. The assessment is done by filling out a questionnaire showing student creativity.

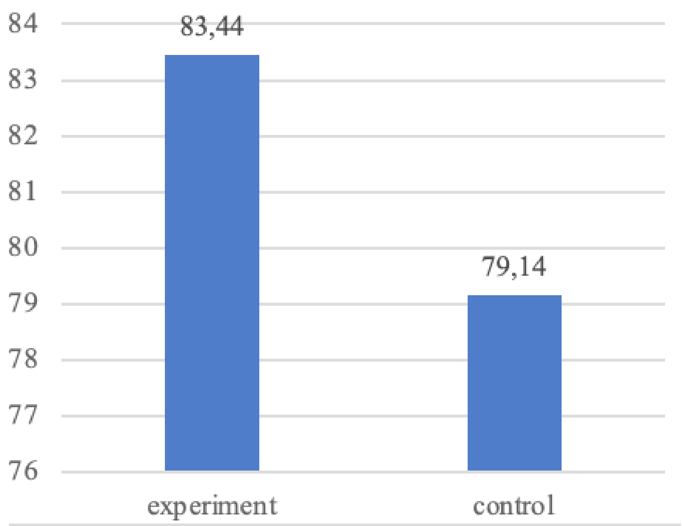

Figure 1. Post-test Results

Figure 2 shows that 12 students obtained values with creative criteria, 19 students with moderate creative criteria, 4 with less creative criteria, 1 with uncreative (poor) criteria, and no with very creative criteria. Therefore, this shows that the assessment of creativity using mind maps is included in the moderate creative criteria.

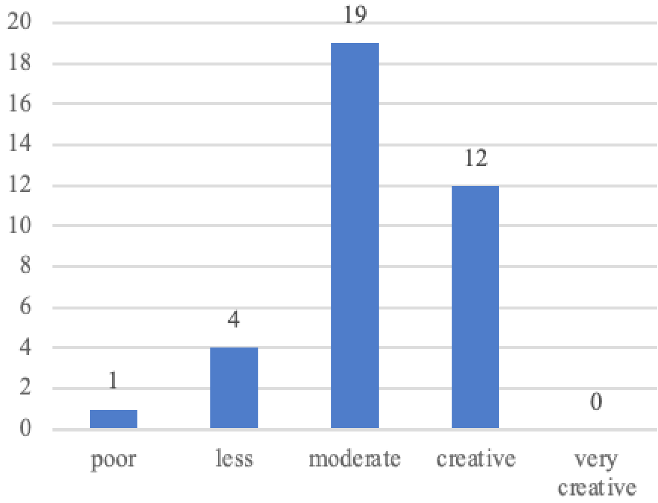

Figure 2. Student Creativity Results

Student creativity channelled through a mind map is assessed based on indicators of creativity, namely fluency, flexibility, elaboration, and originality. The average score for all creativity indicators is 0.64, presented in Table 3 below.

Table 3. Creativity Indicators of Results

No.	Indicator	Value	Category
1.	Fluency	0,63	Fair
2.	Flexibility	0,64	Fair
3.	Originality	0,65	Fair
4.	Elaboration	0,66	Fair
Average		0,64	
Category		Fair	

The preliminary test is used to ensure that the study data is normal and homogeneous. In this study, the Shapiro-Wilk test is employed to calculate the normality test, and the results are provided in Table 4 below.

Table 4. Normality Test Results

	Experimental Class	Control Class
Sig.	0,139	0,052
Shapiro-Wilk test	Normal	

Based on Table 4, it is known that the experimental class gets a significance value of 0.139. This value is greater than the significance value of 0.05. Thus, the post-test data in the experimental class is distributed normally. The post-test data in the control class is distributed normally with a significance value of 0.052 > 0.05.

A homogeneity test is carried out to determine whether the sample studied in the experimental and control classes has a homogeneous variant. The homogeneity test is carried out on two data: the post-test of the experimental class and the control class. The homogeneity test in this study using Lavene Statistics through the SPSS 29 software can be seen in Table 5 below.

Table 5. Homogeneity Test Results

Data	Sig.	Conclusion
Post-test of the Experimental and Control Classes	0,588	Homogeneous

Table 5 shows that the significance value obtained in the homogeneity test is 0.588 > 0.05, meaning that the post-test data in the experimental and control classes are homogeneous.

The normality and homogeneity tests show that the post-test data of the experimental and control classes are normally distributed and homogeneous, and that the data utilized is paired data. As a result, the hypothesis test performed is a parametric paired sample t-test.

Table 6. Hypothesis Test Results

Pair 1	f	Sig. (2-tailed)
Post-test of the Experimental and Control classes	5	0,002

According to Table 6, the significant value of the paired sample t-test is 0.002, which equals 0.05. The research hypothesis can be inferred to be accepted, implying that there is an effect of using the PjBL model with the STEM approach on students' conceptual grasp of human movement system content.

Integrating the PjBL model and the STEM approach provides benefits and has the ability to boost students' conceptual comprehension and creativity (Fitriyah & Ramadani, 2021; Aprilia et al., 2023). The learning implementation stages in the research implementation are characterized as very good according to the PjBL syntax using the STEM methodology. PjBL using the STEM approach is implemented as follows: (1) articulating basic questions, (2) assembling project plans, (3) compiling schedules, (4) monitoring, (5) testing results, and (6) evaluating experiences (Maryati, 2018; Muyassaroh et al., 2022).

The initial learning steps begin with essential questions, namely fundamental questions, which will later become the basis for giving project assignments to students (Sari et al., 2019). Essential questions can stimulate curiosity and help students understand their problems. This question can also facilitate and direct students to find creative and innovative solutions (Nagarajan & Overton, 2019).

The second stage is designing project planning, which is carried out jointly between researchers and students. In this study, the researchers, as the project manager, divide students into several groups and guide them to design activities for their projects (Jauhariyyah et al., 2017).

The third stage is compiling a schedule; researchers and students jointly prepare a schedule for PjBL activities. Research activities at this stage are determining the project completion timeline, creating project completion deadlines, and collecting products. The fourth stage is monitoring students and project progress; the researchers monitor the product manufacturing process. At the monitoring stage, the teacher must record all student activities when doing projects (Izzati, 2014). This is done so students are more guided, focused, and precise during the project process. The teacher is fully responsible for monitoring student activities while completing the project (Hartono & Asiyah, 2019).

The fifth stage is testing the results, namely testing and assessing the results utilizing representatives of each group communicating the results of their project in front of other groups (Umi, 2015). This is done so that students better understand the material being studied. Noviyanti (2011) states that when students communicate, such as expressing opinions, discussing, and understanding problems in people's lives, students can gain a better understanding of the learning material. The final stage is evaluating experience; at this stage, researchers and students collectively reflect on the activities and results of projects that have been implemented so that, on the other hand, PjBL, with the STEM approach, runs better (Zuraida & Suryani, 2022).

Becker and Park (2011) discover that the STEM approach has a beneficial influence on student learning. The STEM approach to learning can train students cognitively, skillfully, and effectively; also, students are taught in theory and practice so that students can directly experience the learning process (Septiani, 2016). PjBL and STEM together have a positive influence. The findings of this study show that the PjBL model combined with the STEM approach has an effect on students' concept understanding. STEM-PJBL can improve understanding of concepts, especially at the compiling project stage. At this stage, students begin to collaborate in groups to work on projects. This is in line with Vygotsky's theory of social constructivism. Constructed concepts and knowledge in students' cognitive structures occur when students work and discuss in groups.

According to Lutfi et al. (2018), in PjBL, students may learn concepts through creating products. In STEM learning, there is a process of developing and redesigning (engineering design process) to ensure that students produce their best products. Ralph (2015) examines research that use STEM-PJBL in education. PjBL enhances the development of students' knowledge and skills. Students also believe that PjBL promotes group communication and bargaining.

The PjBL learning model STEM approach has been effectively applied in this project. This implementation can be noticed via the observer's observations of the learning syntax implementation. Observations suggest that the application of learning syntax has a 95.8% success rate. This is very good based on the criteria for applying the learning syntax and suggests that learning with this model has occurred (Firdausichuuriyah, 2017).

According to the discussion and the results, the PjBL model with the STEM approach influences students' concept comprehension. The paired sample t-test findings show a sig. value of 0.002 0.05, indicating that the PjBL model with the STEM approach influences students' concept understanding. According to Tipani et al. (2019), using the PjBL model combined with the STEM approach influences students' concept understanding.

In implementing research, students are guided in preparing project designs to generate a product. In this research, the product produced is in the form of a mind map. Darusman (2014) defines a mind map as a learning approach aimed to increase students' knowledge by creatively combining the key ideas of a concept into a mind map. Mind mapping can be made more interesting by using interesting colors and symbols. This mind mapping is a creative product students produce in learning activities (Siregar, 2014; Parmin et al., 2022).

The PjBL model can encourage students to develop creativity through problem-solving activities (Kusumaningrum & Djukri, 2016). The STEM approach can also develop students' creativity to face future challenges. Learning STEM allows students to directly participate in the design learning process and generate products that are creative and problem-solving oriented (Arsy & Syamsulrizal, 2021). Student creativity is essential to develop. Students can be creative if the student achieves indicators of creativity, including fluency, flexibility, originality, and elaboration (Guilford, 1966).

The student creativity questionnaire tabulation results show the effect of the PjBL learning model combined with the STEM approach on student creativity. The study's questionnaire contains 22 statements. According to the research findings, the average level of creativity is 64.9%. According to Sari (2015), 64.9% of students meet the fair creative requirements based on the criteria for achieving student creativity. This demonstrates that the PjBL model with a STEM approach is effective for learning. This is consistent with the findings of Lou et al. (2017), who reveal that combining PjBL with a STEM approach improves the effective development of creativity.

CONCLUSION

According to the study's findings, applying the PjBL model combined with the STEM approach affects students' conceptual grasp and creativity in human movement system material. This is demonstrated by the paired t-test significance value of 0.002. The evaluation of product creativity in the form of a mind map yields a value of 0.64, which falls into the fair category.

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