STEM-Based Biology Instruction Using an Inquiry-Based Learning Approach to Foster Students' Creative Thinking

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Abstract. The development of creative thinking abilities is crucial because it helps kids become more adaptable to changing circumstances. In order to meet the difficulties of the twenty-first century, these talents are equally crucial. Through creative learning methods like STEM-based learning and inquiry learning models, this talent may be fostered. The purpose of this study was to determine how STEM-based biology instruction using inquiry learning models affected the development of creative thinking skills. This study was carried out at SMA Lab UM's class X. First class served as an experiment, while the second class served as a control. the testing-based data collecting. A one-way Anakova test was used to analyze the data. The data collection by test. the testing-based data collecting. A one-way Anakova test was used to analyze the data. The study's findings show that STEM-based biology instruction can improve pupils' capacity for original thought.

Keywords: STEM, Inquiry-Based Learning, Creative Thinking

1 Introduction

The 21st century is characterized as a century of openness. This era provides great opportunities for nations in the world to interact with each other. Mastery of science and technology (IPTEK) is an important key to facing future challenges. This development has an impact on aspects of life in the fields of economy, transportation, communication technology, and information [1]. So that various skills are needed to face life's challenges.

Skill development can be done through learning science [2]. This learning provides an opportunity for students to know fact, concepts or principles that can be applied in everyday life. This process also provides opportunities for students to develop students' creative thinking skills. Creative thinking is a dimension of thinking [3]. Creative thinking is an activity of cognitive thinking [4] as a process of forming concepts and understanding [3] by using imagination [5] to explore ideas and propose alternative innovations [3] as solutions to problems [4] by combining various approaches. Four categories can be used to categorize creativity: (1) Coming up with concepts that exhibit fluency, flexibility, creativity, elaboration, and metaphorical

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thinking; (2) Delving deeper into concepts; (3) Being open and courageous enough to investigate concepts; and (4) Paying attention to one's "inner voice" [6].

Aspects of creative thinking skills consist of; (1) curiosity by conducting investigations, asking questions, and seeking deeper meanings; (2) fluency (fluency) by generating of ideas; (3) originality by generating new, fresh, unique ideas; (4) elaboration; (5) imagination (imagination); (6) flexibility [7].

Creative thinking skills play an important to develop and new discoveries in the field of science and technology [8]. These skills will also increase students' self-productivity in the industrial revolution 4.0 era [9]. The integration of creative thinking skills into the science learning process is good when teachers use inquiry learning cause science process skills can be linked to creative thinking [10].

The results of research on creative thinking skills also show that they still need to be developed [4,11]. The low students' creative thinking skills are caused by; 1) teachers have not found the right way to develop creative thinking skills [12]; 2) applied learning does not familiarize students with developing creative thinking skills [13,14].

The findings of learning observations concur with those of earlier research. At the SMA Laboratory, State University of Malang, a needs analysis was performed by administering a questionnaire to evaluate the requirements of teachers and students in October 2019. The problems found were; 1) students are still not trained enough in the inquiry process; 2) the process of students acquiring knowledge through direct teacher explanations and the internet; 3) learning activities do not train students in innovating. It can be seen from the LKS that is used that still focuses on concepts; 4) learning has never been associated with STEM because it is not familiar.

Efforts that can be made to overcome the problems above are by implementing STEM-based learning through the inquiry learning model. STEM was chosen because this learning is an integrated of four disciplines STEM [15]. STEM is more than just an integration of four fields of knowledge, but as an innovation [15] and an applied process in designing solutions to contextual problems [16].

The results of previous research show that STEM learning has been widely applied in learning. Meanwhile, the application of STEM learning in the field of biology studies is still lacking. STEM learning will be applied to ecosystem material and environmental change. This material was chosen because ecosystem and environmental problems are one of the complex problems in life, so it requires innovative solutions as an effort to solve these problems. The purpose of this learning is to evolved students who are STEM literate and also have the desire to be involved in STEM-related issues (eg environmental quality) which will be solved using the ideas of STEM.

Curriculum policies, such as project-based learning (PjBL) and inquiry-based learning, have been designed to help students develop their abilities via the application of scientific knowledge. Students must have the ability to interpret natural occurrences, design, and make conclusions based on the data gathered in order to achieve the STEM education goals. Investigative learning activities can be used to acquire these competencies [9,17].

Learning model is one that involves students through a process of inquiry [18]. This learning directs students to seek information or knowledge through questions [19]. This learning prepares students to think and act like real scientists [20] through questions [20,21], make hypotheses, and carry out investigations using scientific practice [20] to build understanding, new meanings and knowledge [21]. The results of the study explain that the application of inquiry learning in the learning process helps improve creative skills [22], and allows students to have in-depth and structured knowledge [23]. Based on the context that has been provided, the goal of this study was to determine how STEM-based biology instruction using an inquiry paradigm affected high school students' capacity for creative thought.

2 Method

This investigation is a quasi-experimental investigation. The study was place in the class X IPA SMA Laboratories UM. Based on the outcomes of the equivalency test for all X IPA classes, classes were chosen. There were two classes in the research course. The first class served as the control and the second as the experimental group. Nonrandomized control group pretest-posttest was the method utilized in the study. Table 1 displays the research strategy. This study focused on KD 3.10-4-10, which deals with ecosystems, and KD 3.11-4.11, which deals with environmental change.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
experiment	O1	X	O2
control	O1	-	O2

The learning process in the experimental class applies the inquiry learning model and uses worksheets. LKS is used as a student guide. Learning activities use inquiry syntax by integrating aspects of STEM that are appropriate to the learning syntax. The learning process in the control class uses modules and worksheets developed by the subject teacher. The learning methods in the control class are discussions and presentations.

The data collection instrument uses a test of students' creative thinking skills. The test results are assessed based on the rubric that has been prepared. The data obtained were analyzed using covariance analysis with the help of SPSS 16 for windows at a significant level of 5%. Prior to the Anakova test, the data were tested for normality with the Kolmogorov-Smirnov and homogeneity tests with Levene's Test of Equality of Errors Variances.

3 Result and Discussion

The study's findings contained information on students' capacity for creative thought from a pretest through a posttest. Analyzing the results of the homogeneity, normality, and Anacova tests included the data analysis. Table 2 displays the outcomes of the data normality test for students' capacity for creative thought.

Table 2. Results of Normality Test for Creative Thinking Skills Data

Variable	Statistical	Sig (2-tailed)	Alpha	Description

Data Pretest Creative Thinking Skills	0.835	0.488	0.05	Normal
Data Posttest Creative Thinking Skills	0.584	0.885	0.05	Normal

Table 2 shows that the data on students' creative thinking skills is normally distributed with a significance value of sig (2-tailed) or the p value of the pretest data, namely p (=0.488) > α (0.05) and the posttest value is p (=0.885) > α (0.05). Data is said to be normal if the absolute value (p) is greater than 0.05. prerequisite test then homogeneity test. The homogeneity test results can be seen in Table 3.

Table 3. The Results of The Creative Thinking Skills Data Homogeneity Test

Variable	F Value	df	Sig	Alpha	Description
Data Pretest Creative Thinking Skills	3.107	65	0.083	0.05	Homogeny
Data Posttest Creative Thinking Skills	3.312	65	0.073	0.05	Homogeny

Table 3 shows that the data on students' creative thinking skills is homogeneous with the pretest p value p(=0.083) > α (0.05) and the posttest p value is p(=0.073) > α (0.05). Furthermore, the Anacova test to determine the effect of learning by looking at the differences in data from the experimental class and the control class. The results of the Anakova test on creative thinking skills data can be seen in Table 4.

Table 4 of the Anacova test shows that the significant value obtained is p (=0.022) > α (0.05) so that it can be stated that there are differences in the creative thinking skills of the experimental and control class students. This result is supported by the corrected mean values of both classes. The experimental class obtained a corrected mean value of 60.38, which was greater than the control class, which was 49.20. The corrected average data for creative thinking skills can be seen in Table 5. The corrected average value proves that the experimental class is significantly significant compared to the control class in improving students' creative thinking skills. So that it can be concluded that there is an influence of STEM-based learning through the inquiry model on students' creative thinking skills.

The findings of the hypothesis test demonstrate that STEM-based biology instruction using the inquiry learning methodology has an impact on students' ability to think creatively. The difference in the adjusted average between the treatment class and the control class is another indicator of how well learning has been applied. The treatment class's adjusted mean value was 60.38, compared to 49.20 for the control class. Students' ability to think creatively is enhanced through inquiry learning syntax and practiced through student worksheets (LKS).

Table 4. Anacova Test Results Data for Creative Thinking Skills

Source of Variation (SV)	Number of Square	df	Average of square (RK)	F	Sig.(p)
Corrected Model	3129.016a	2	1564.508	13.599	.000
Intercept	6856.363	1	6856.363	59.598	.000

Pretest	1037.391	1	1037.391	9.017	.004
Class	637.238	1	637.238	5.539	.022
Error	7362.748	64	115.043		
Total	212286.621	67			
Corrected Total	10491.763	66			

Table 5. Summary of Corrected Average Creative Thinking Skills in Experimental and Control Classes

Class	Pretest	Posttest	Deviation	Corrected Average
Experiment	38.77	60.39	21.62	60.38
Control	29.26	49.21	19.95	49.20

Phenomenon exploration activities and focusing on student questions (STEM aspect: science). This activity is a trigger for students' curiosity to make questions and answers from various different perspectives about a given phenomenon. Students' curiosity can be trained by doing research [7]. Based on the learning process carried out by students, the questions and answers that appear are very varied and from various points of view. The process of making questions and answers trains students to think flexibly and fluently.

The next activity, students carry out investigations to verify the answers to their questions based on the results of the investigation obtained. This activity helps students to build new knowledge by linking previous knowledge with new knowledge. The results of this activity, students are able to create an idea as a problem solving. One example of the activity on the LKS is the implementation of knowledge. STEM Aspects integration at this stage are science, technology, engineering, mathematics. At this stage, students are trained to design a simple technology by considering the results of previous investigations. However, some students are still unable to make simple technological designs. This is because the learning process is carried out online causing students to have difficulty designing simple technologies that integrate STEM aspects. Students also have difficulty making designs because they are not used to it and have not been trained.

The last activity communicates knowledge and design results have been made. Achieving STEM goals can be done by giving students practical learning, developing curiosity, being able to carry out investigations, and carrying out collaborative innovations [20]. STEM aspects that are integrated at each stage of inquiry learning indirectly train students in integrating the four disciplines. The purpose of this integration is to prepare competitive students by being able to master the fields of science, technology, engineering, and mathematics [24].

4 Conclusion

The findings demonstrated that STEM-based biology instruction using the inquiry paradigm might enhance students' capacity for original thought. In order to enhance students' capacity for creative thought, this approach is anticipated to be used repeatedly to various materials over a longer period of time. Because they are 21st century talents necessary for overcoming future obstacles, creative thinking abilities must be developed.

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