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Analysis of Creative Attitudes and Cognitive Learning Outcomes of High School Students Using the STEM Approach on Excretory System Materials

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Abstract

Integration of STEM (Science, Technology, Engineering, and Mathematics) in learning combines multiple scientific disciplines to create meaningful and integrated learning experiences. This study aimed to determine the effect of the STEM approach on students' cognitive learning outcomes and creative attitudes in learning the excretory system at SMAN 1 Sirenja. The research employed a quasi-experimental design involving all students of class XI IPA as the research population. A total of 40 students participated in the study, consisting of 20 students in the experimental class (XI IPA 1) and 20 students in the control class (XI IPA 2). Samples were selected using a saturated sampling technique, in which all members of the population were included as research participants. The collected data were analyzed using SPSS version 22. The findings indicated that the STEM approach significantly improved students' cognitive learning outcomes, with the experimental class obtaining a mean score of 75.10 compared to 50.45 in the control class. In addition, the STEM approach positively influenced students' creative attitudes toward learning the excretory system. These findings suggest that STEM-based learning can serve as an effective instructional approach and may be considered by teachers as an alternative strategy to improve learning and creativity.

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Introduction

The 2013 curriculum mandates the essence of a scientific approach in learning. The scientific approach is believed to be the golden footbridge for the development and development of attitudes, skills and knowledge of students. The scientific approach refers to investigative techniques on phenomena or phenomena to obtain new knowledge or correct and integrate it with previous knowledge. These abilities will be owned by students who are able to be creative.

Creative attitude is a tendency to behave that produces creativity or new ideas in dealing with a problem. Students who have a high creative attitude are able to generate new ideas or ideas and do not easily give up in solving a problem. However, there are also students whose creative attitude is low so that they are less than optimal in learning (Farida, 2014). There are six criteria for being creative, namely curiosity, fluency, originality, breadth, imagination, and suitability (Monty et al., 2003). The ability of students' creative attitudes will also affect their learning outcomes.

Learning outcomes are an achievement of one's abilities based on the learning process so as to produce changes in attitudes, learning outcomes into three domains, namely cognitive, affective, and psychomotor learning outcomes. Of the three domains that are in the public spotlight are cognitive learning outcomes. Cognitive learning outcomes include behavior that emphasizes intellectual aspects, such as knowledge and thinking skills (Arikunto, 2009).

Thinking skills refer to cognitive processes, namely a mental activity that emphasizes reasoning to acquire knowledge. The thought process as implementation within the framework of cognitive intellectual abilities is the ability of students to recognize difficult theories and refers to students' ability to understand the meaning of the material. Such thinking skills are needed in 21st century learning. According to Sumarni et al (2019) in stem classes, students are trained to be more active in looking for answers in each given problem, to be more active in creative ideas, to get faster at information, to better produce results, and to be more effective at providing solutions to the problems they encounter.

STEM is a new learning in the world of education (Handayani et al., 2020). The STEM approach can shape students into human resources who are able to be creative, systematic and logical. The STEM approach requires students to play an active, creative role in the learning process, because in this learning process it is not only classroom learning that is studied, but learning related to the environment, so students are required to think critically and have a creative attitude. During the learning process, students are guided to be able to do all aspects contained in the function of being

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creative. This is supported by the results of Herak & Lamanepa (2019).

The application of the STEM approach is to integrate the four disciplines of science, technology, engineering and mathematics into biology learning, where biology learning itself examines natural science, technology, engineering and calculations (Syarah et al., 2021). Furthermore, Afriana et al (2016) suggested that the STEM approach in learning is expected to produce meaningful learning for students through the systematic integration of knowledge, concepts, and skills.

Syukri (2020) explained that there are seven important steps in the engineering process, namely ask, research the problem, imagine, plan, create, Test and Evaluate Prototype, and improve. In STEM classes, students are required to solve real-world problems and engage in illdefined tasks to become well-defined outcomes through teamwork (Han et al., 2015).

The implementation of the STEM approach can be carried out at the secondary school level, especially in learning biology in class XI IPA material on the excretory system. The material of the human excretory system is one of the subjects that is quite complex so it is necessary to simplify the concepts so that they are easier to understand. However, in fact the excretory system material in humans has been previously taught at SMAN 1 Sirenja and the methods used to instill concepts focus more on students' memorization skills. This causes students to understand less about the application and benefits of the material in everyday life.

The results of interviews with teachers of biology subjects, especially the excretory system material, on initial observations at SMAN 1 Sirenja that the special strategies for excretory system materials and methods applied by teachers in biology lessons paid less attention to the process of knowledge formation. Most of the learning process is teacher-centered, because teachers are less creative in designing interesting ways of delivering material. As a result, students tend to be silent and less active, lack motivation, and lack confidence in answering questions during the learning process. Thus the material being taught becomes less meaningful for students. In addition, as a result of interaction and communication between teachers and students as well as between students did not go well so that it could not improve students' creative attitudes. This is the cause of the low score of completeness. The minimum completeness score achieved by class XI students in 2020/2021 in biology is 75, which is below the criteria set by (Siregar, 2021).

The phenomena found in students of class XI IPA 1 and 2 are important to be given special attention, especially applying the right way to give birth to students' creative attitudes and better learning outcomes. The STEM approach has the potential to be an alternative that should be tried to apply to biology learning, especially the excretory system subject because the STEM approach has never been applied before to biology learning at SMAN 1 Sirenja, therefore it becomes interesting to conduct research.

Materials and Method

This research is a quasi-experimental research. Quasi-experimental research is research that is close to real research. This study aims to directly test other variables and test the causal hypothesis (Ahmad & Rahmi, 2017).

This research activity has been carried out at the SMAN 1 Sirenja school in class XI IPA. The sample used in the study amounted to 40 students, 20 students came from class XI IPA 1 which was the experimental class and 20 students came from class XI IPA 2 which was the control class.

Data analysis includes creative attitudes and student cognitive learning outcomes.

1. Creative Attitude

The observation sheet is adjusted to the indicator of the ability to be creative, consisting of: curiosity, imaginative (strength or process of producing images and ideas, original in the expression of ideas (can provide answers or questions given according to their own thoughts), ask questions, many ideas, freely express opinion, looking at the problem from various points of view (Munandar, 2006).

How to calculate the percentage score of the creative attitude observation sheet using the formula by Sugiyono (2013).

$$N = \frac{\text{Jumlah Skor Pencapaian per Indikator}}{\text{Jumlah Skor Maksimal per Indokator}} \times 100\%$$

2. Student Cognitive Learning Outcomes

The test contains multiple choice questions with a total of 25 questions, with 5 answer choices for each question number. This written test is structured based on basic competencies. Multiple choice questions refer to the cognitive aspects and knowledge of Bloom's taxonomy C2-C5.

Before testing the hypothesis, the analysis prerequisite test is carried out, namely the normality test and homogeneity test with the help of the SPSS 2.2 application.

Results and Discussion

Based on the research that has been done, the following results are obtained.

Creative Attitude

Descriptive Analysis

Descriptive analysis is useful for describing and describing research data including the amount of data, maximum value, minimum value, average value, and so on. The results of the descriptive

analysis can be seen in Table 1.

Table 1. Descriptive Analysis of Creative Attitudes

	N	Min	Max	mean	Std. Dev
Experiment Class	20	30	50	39.75	5.955
Control Class	20	15	35	24.00	5.282
Valid N (listwise)	20				

Table 1 shows that N or the amount of data for each valid variable is 20, and the average value (mean) in the experimental class is 39.75 and the control class is 24.00. Thus, it can be concluded that the experimental class that was treated with the STEM approach had a higher score than the control class.

Normality test

Normality testing is intended to determine whether the analyzed data comes from a normally distributed population or not. The normality test of research data uses the Shapiro-Wilk test method with the basis for making decisions in the normality test, namely if the significance (Sig.) < 0.05 then the data is not normally distributed while if the significance (Sig.) > 0.05 then the data is normally distributed. The results of the analysis of the data normality test that all data on the Shapiro Wilk test 0.112> 0.05 and 0.128> 0.05, it can be concluded that the students' creative attitude data is normally distributed and can be used parametric statistics (paired sample t test and independent sample t test test) to analyze research data.

Homogeneity Test

The homogeneity test aims to determine whether a data variance from two or more groups is homogeneous (same) or heterogeneous (not the same). The basis for decision making is if the significance value (Sig.) < 0.05 then the data variance from two or more groups is heterogeneous (not the same), if the significance value (Sig.) > 0.05 then the data variance from two or more groups is homogeneous. The results of the homogeneity test analysis obtained that the significance value (Sig.) Based on Mean was 0.566 > 0.05, so it can be concluded that the variance of the experimental class data and the control class data is the same or homogeneous.

Hypothesis testing

Hypothesis testing or independent sample t test was used to determine whether there was a difference in the average of two unpaired samples, namely to determine the creative attitude of students in the experimental class using the STEM approach compared to the effect of the conventional learning approach in the control class. Independent sample t test was conducted on experimental class data with control class data. The results of the independent sample t test analysis can be seen in Table 2.

Table 2. Independent Sample T Test Creative Attitude Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Creative Attitude	Equal variances assumed	.351	.557	8.849	38	.000	15.750	1.780	12.147	19.353
	Equal variances not assumed			8.849	37.466	.000	15.750	1.780	12.145	19.355

The results in Table 2, obtained the value of Sig. (2-tailed) of 0.000 < 0.05. The creative attitude of the control class students (μ = 24.00; SD = 5.282) was significantly lower than the experimental class (μ = 39.75; SD = 5.955, t = 8.849, P 0.001. Thus H0 is rejected, meaning there are class differences experimental and control classes, the difference is due to the influence of the application of STEM.

Student Cognitive Learning Outcomes

Descriptive Analysis

The results of the descriptive analysis can be seen in Table 3.

Table 3. Descriptive Analysis of Student Cognitive Learning Outcomes

	N	Min	Max	mean	Std. Dev
Experiment Class	20	60	90	75.10	7.966
Control Class	20	33	67	50.45	11.076
Valid N (listwise)	20				

The results in Table 3 show that N or the amount of data for each valid variable is 20, and the average value (mean) in the experimental class is 75.10 and the control class is 50.45. Thus, it can be concluded that the experimental class that was treated with the STEM approach had a higher score than the control class.

Normality test

The results of the analysis of the normality test showed that the significance value (Sig) on the Shapiro Wilk test was 0.106 > 0.05. For the experimental class 0.106 and the control class 0.249, it can be concluded that the students' cognitive learning outcomes data are normally distributed and parametric statistics can be used (paired sample t test and independent sample t test) to analyze research data.

Homogeneity Test

The results of the homogeneity test analysis showed that the significance value (Sig.) Based on Mean was 0.122 > 0.05, so it can be concluded that the variance of the experimental class post-test data and control class post-test data is the same or homogeneous.

Hypothesis testing

The results of the analysis of hypothesis testing can be seen in Table 4.

Table 4. Independent Sample T Test of Student Cognitive Learning Outcomes

		Levene test for differences Equality		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Results Study	Equal Variances Assumed	4.871	.033	8.080	38	.000	24.650	3.051	18.474	30.826
	Equal Variances Note Assumed			8.080	34.508	.000	24.650	3.051	18.453	30.847

The results in Table 4, obtained the value of Sig. (2-tailed) of 0.000 < 0.05. The cognitive learning outcomes of the control class (μ = 50.45; SD = 11.076) were significantly lower than that of the experimental class (μ = 75.10; SD = 7.966, t = 8.080, P 0.001. Thus H0 is rejected, meaning that there is a class difference experimental and control classes, the difference is due to the influence of the application of STEM.

Student Creative Attitude

A problem can be solved by using a creative attitude which is one form of creativity. Creative attitudes can be developed in learning at school. The students' creative attitude in this study was measured using an observation sheet.

The results of data analysis on the assessment of creative attitudes there are differences in attitudes that occur in the experimental class using the STEM approach and the control class using conventional learning. The findings that have been collected from the results of the independent t-test analysis are known that the sig. (2-tailed) of 0.000 <0.05 so rejecting H0 and accepting H1 is that there is an effect of the STEM approach on students' creative attitudes. The creative attitude of students was observed directly by looking at seven indicators of observation, namely curiosity, imaginative, original in expressing ideas, asking questions well, having lots of ideas, being free to express opinions, and seeing problems from various points of view.

The results of the analysis of students' creative attitudes showed that the experimental class had a good creativity attitude. Both from the point of view of students, how students think, how are students' ideas, how are students' imaginations, how are students' curiosity and originality of students in expressing their ideas.

The results of the analysis prove that the STEM approach can grow or improve students' creative attitudes. The attitude of the teacher in this STEM approach can help develop student creativity by motivating students. The teacher gives freedom to students in giving ideas, looking for alternative answers and solving a problem, then the motivation in students can grow. In this study, the experimental class/class with the STEM approach treatment produced a product, namely a 3D image of the excretion system, this activity made it possible to foster a creative attitude in students. In accordance with the research results of Widana & Septiari (2021) that the STEM approach affects the ability of students' creative attitudes. The mindset, logic, and reasoning that are trained continuously can trigger students' creative thinking abilities. Meanwhile, Lumbantobing & Azzahra (2020) stated that the application of STEM learning was able to train students' scientific and rational attitudes. With this ability students will be able to find creative ways to solve a problem or generate interesting ideas in the future.

Likewise the results of this study, that the benefits of the STEM approach make students able to solve problems to be better, innovative, independent, logical thinking, and technological literacy (Morisson, 2006). Students at the senior secondary level need to be challenged to perform authentic engineering tasks as a complement to science learning through project activities that integrate science, engineering, technology, and mathematics (Bybee, 2013). Through project activities or mini research (mini research) students in class can be empowered to learn literacy-oriented science/biology by examining components related to the dimensions of students' thinking development.

Student Cognitive Learning Outcomes

Student learning outcomes on the excretory system material taught in class XI IPA 1 as an experimental class with STEM approach learning and XI IPA 2 as a control class with conventional learning. Based on the average cognitive learning outcomes of students after treatment for the experimental class was 75.10 and the control class was 50.45. These data prove that in both classes there is an increase in learning outcomes. The experimental class that was given the STEM approach treatment resulted in a higher learning outcome score than the control class with the conventional learning model, so it can be said that the STEM approach was more effective than the conventional learning model.

The results obtained are supported by the results of the independent t test analysis, namely the sig value obtained. (2-tailed) of 0.000 <0.05 so that it accepts H1 which means that there is an effect of the STEM approach on students' cognitive learning outcomes, meaning that there are differences in cognitive learning outcomes in the control class and the experimental class.

The theory that can support these findings was put forward by Handayani, et al (2020) that the STEM approach is a learning approach that can be done using several disciplines, namely science, technology, engineering, and mathematics. Learning that integrates the STEM approach requires students to understand the concept of science and analyze the engineering of a technology so that it is useful for training and supporting students' creative thinking skills.

Lestari and Rahmawati (2020) revealed that learning with a STEM (Scince, Technology, Engineering and Mathematics) approach is learning that combines 4 components, namely science, technology, engineering, and mathematics in one lesson and students use technology to prove scientific concepts supported by data. In addition, Ceylan & Ozdilek (2014) argue that the STEM approach focuses on student activities to think logically, critically, evaluatively, creatively in solving problems and making decisions to identify questions and problems in life situations.

The results showed that the control class that used conventional learning was less active in the learning process, and when working on the LKPD students could not do it as a result, the score of knowledge value on the material being taught was lower than the experimental class. In accordance with the explanation by Superni (2018) that conventional learning refers to behavioristic learning theory. Behavioristic theory does not provide opportunities for students to explore their own knowledge so that learning is seen as a process of imitation. The influence of conventional learning models in science learning tends to be oriented to the material listed in the curriculum and textbooks. When the teacher explains the material, students tend to be apathetic to what the teacher explains.

Learning activities carried out in the experimental class with 4 stages, namely Science: The teacher helps students to be interested in new concepts regarding the expression system through short activities to trigger curiosity. The activities carried out are connecting prior knowledge with learning experiences that will be carried out by students. Technology: In this stage, students learn to use laptops or gadgets to search the internet, and focus as a tool to help solve problems given by the teacher. Engineering: at this stage the teacher provides opportunities for students to engineer, namely a combination of combining knowledge that students already know with new knowledge that has been obtained through internet searches and books that have been done previously, namely by producing a product, namely a 3D image of the excretion system which will then be explained. Mathematical: at this stage students are challenged to expand their conceptual understanding and skills by connecting the excretory system such as the amount of water needed by humans to be able to relate it to human body weight and age.

Interest and be actively involved in learning, and make connections. The results of the STEM Approach are learning and achievement, mastering 21st century competencies, persistence and persistence in learning to improve achievement, being ready for STEM-related work, increasing STEM interest, developing STEM identity and the ability to make connections between STEM disciplines.

The results of the independent test show that the STEM approach has an influence on students' cognitive learning outcomes. From the average value of the highest student cognitive learning outcomes in the experimental class, the average value in the control class is lower. Because the stages in the STEM approach are able to make students' attitudes more active and can make students skilled, critical, and creative towards natural events. This agrees with Herak (2021) that the learning outcomes of the STEM model further improve student learning outcomes than conventional learning. Improving student learning outcomes proves that teachers are able to implement the syntaxes in the STEM model.

The results of research conducted by Banila et al (2021) who carried out a blended learning model with the STEM approach proved that the STEM approach can improve scientific literacy in students. So that students have a better understanding of scientific literacy, students' understanding of science must continue to be trained. The explanation above proves that the STEM approach can be carried out in a network (online) and outside the network (offline).

Conclusion

The STEM approach has a significant effect on students' creative attitudes and cognitive learning outcomes, namely the experimental class is 75.10 and the control class is 50.45.

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