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THE EFFECT OF PROJECT BASED LEARNING MODEL WITH STEM APPROACH TO STUDENTS' CRITICAL THINGKING SKILL ON HUMAN EXCRETION SYSTEM

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ABSTRACT

This study was aimed to determine the effect of Project Based Learning Model with STEM approach to students' critical thinking skills on Human Excretion System material in class 8th grade at SMP Negeri 37 Medan. This research used quantitative methods with the type of research quasi experiment with pretest-posttest control group design. The sample of this study consisted of two classes randomly selected by simple random sampling technique, namely in class VIII-D and VIII-F. The first sample is an experimental class that was taught using the PjBL-STEM learning model, and the second sample is a control class that was taught using conventional learning methods. The research instrument that was used included critical thinking skills test instrument using essay questions totaling 5 questions. Analysis of research data used the Independent Sample T-Test test using SPSS version 26.0. The pretest data results of students' critical thinking skills in class VIII-D and class VIII-F are 33.71 and 29.35. After obtained the results of the initial ability of students by looking at the pretest results in both classes, class VIII-D was selected as the experimental class and class VII-F as the control class. The posttest data in the experimental class and control class are 80.00 and 52.58. Based on the hypothesis test, the calculated t_{value} is 12.761 > t_{table} 1.671, and the significance value is 0.000 < α, with α = 0.05, so H_0 is rejected and H_a was accepted, which meant that there was an effect of the PJBL-STEM model on the critical thinking skills of students on the material of the excretory system. The influence of the PJBL-STEM model on students' critical thinking skills was categorized as strong with a cohen's d value of 3.242. It can be concluded that the PJBL-STEM model have an effect on students' critical thinking skills with a strong effect category.

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INTRODUCTION

Education has a crucial role in forming the next generation of a nation that is qualified, productive, innovative, creative, has character, and contributes to the life of society, nation, and state in today's modern era. There is a need to improve the quality of education that can be adjusted to the development of science and technology, which has entered the 21st century (Tipani et al., 2019). The development of the 21st century demands that everyone has various skills to produce quality human resources and compete in the increasingly rapid changes of times (Septiani et al., 2019). Students must possess educational skills in the 21st century, including critical thinking skills, collaboration, communication, and creativity, or 4C (Zubaidah, 2019).

Critical thinking skills are one of the 21st century skills that students need to have to deal with various problems and challenges in life (Nuryanti et al., 2018). This is in line with what was conveyed by the Partnership for 21st Century Skills (P21), Assessment & Teaching of 21st Century Skills (ATCS21S), and UNESCO that critical thinking skills are recommended to be developed in students to gain meaningful knowledge (Billah et al., 2021). Critical thinking is reasonable and reflective thinking that focuses on deciding what to believe or do (Ennis, 1985).

Critical thinking skills are thoughts that are always curious about existing information to achieve a deep understanding (Yustyan, Widodo & Pantiwati, 2015). Critical thinking skills need to be developed and possessed in students because, through critical thinking skills, students can deal with various problems, formulate, be innovative, and design appropriate solutions to the problems they face (Aini, 2020). In line with that, Tiruneh et al., (2018) also stated that students who have critical thinking skills could help the success of learning because critical thinking, apart from involving processes, also involves thinking skills such as predicting, analyzing, synthesizing, evaluating, reasoning so that students can achieve learning objectives.

Natural Sciences is a science closely related to everyday life, which helps students solve problems related to the natural surroundings. Science learning in the 21st century, based on the National Science Teacher Association (2006), must be able to prepare students with critical thinking skills. The critical attitude of students is the key to success for learning outcomes and benefits for the surroundings. The natural science dimension consists of processes, products, and attitudes related to critical thinking, whereas there are processes related to scientific methods, such as observing and exploring (Ramdani et al., 2020). Critical thinking plays a role in science learning to provide opportunities for students to increase criticism, arguments, and questions that train scientific thinking; encourage students to criticize or review existing knowledge; critically compare evidence; and dare to give feedback. Armed with critical thinking skills, teachers have helped prepare students for their future (Rahmawati et al., 2019).

In fact, the science learning process in Indonesia still needs to direct students to improve their critical thinking skills. Several international survey results prove that the critical thinking skills of Indonesian students are still relatively low. The 2018 PISA (Program for International Student Assessment) results for math ability and science ability, Indonesia is ranked 73rd and 71st out of 79 PISA participating countries (Organisation for

Economic Co-operation and Development, 2019). The questions used in the PISA study consist of contextual problems in everyday life that require critical thinking skills to answer these questions (Suprayitno, 2019). Furthermore, in the 2015 TIMSS (Trend In International Mathematics and Science Study) research, Indonesia ranks 69th out of 76 TIMSS participating countries. TIMSS is an international study of mathematics and science achievement for junior high school students coordinated by The International Association for the Evaluation of Educational Achievement (Hadi & Novaliyosi, 2019).

Based on the results of pre-research conducted by researchers with observations and results of interviews with one of the science subject teachers, it was found that students critical thinking skills had not been seen and were still relatively low. The results of observations and interviews obtained from the teaching and learning activities carried out by the teacher are: 1) the science learning process which is carried out is still dominant using the lecture method, which makes students sit and listen to the material, tends to be passive and must always be directed by the teacher; 2) students have not been able to provide a simple explanation of the material to be studied; 3) students have not been able to answer the teacher's questions with their thoughts and only focus on memorizing theory; 4) students are less active in looking for other sources of information, the learning resources they use are only focused on textbooks so that the ability to find and process information is less trained. 5) learning with group activities has yet to be seen, learning is only teacher-centered and does not implement learning models in class 6) the students' low critical thinking skills, as seen from the acquisition of cognitive learning outcomes, the daily test scores for science subjects in 8th grade are still below the average, where the KKM (Kriteria Ketuntasan Minimal) for science subjects is 75. The average daily test scores for science subjects in classes VIII-A and VIII-B are 50 and 40.

The problems above indicate that the classroom learning process has yet to foster students' critical thinking. Based on research by Afifah et al., (2019), the lecture method, which only sits, listens, and silent, makes students less able to absorb information obtained from the teacher and doesn't optimize students' roles in learning so that students are not actively developing and honing. Being active does not mean only having the courage to express opinions, but students have a basis for the opinions or questions submitted (Dywan & Airlanda, 2020). In addition, conventional learning methods do not use technology; this is not by the nature of science, which includes attitudes, processes, products, and applications (Hamdani et al., 2019). According to Fitriyani et al., (2020), learning that is still training in rote learning makes it easy for students to forget the material they have learned. Students will find it difficult to answer questions different from the example questions in their textbooks. As a result, when they repeat, they need help to answer the test questions correctly. Low learning outcomes indicate that students' critical thinking skills are also still low (Wahyuni, 2018).

Human Excretion System material is one of the materials contained in science subjects for class 8th grade in Junior High School. Human Excretion System material is abstract, where observations cannot be made directly, so students need an overview. Students can easily understand abstract material if the teacher uses tools such as visual aids or others that can provide an overview of the material being studied. In addition, the Human

Excretion System material requires thinking skills to understand the structure and function of each organ included in the human excretion system (Ratnasari et al., 2018). Based on the description of the problems above, efforts must be made to stimulate students' critical thinking skills. Choosing a suitable learning model can foster students' critical thinking skills. One learning model that can involve students actively in the learning process is the Project based Learning (PjBL) model (Rahmania, 2021).

The PjBL model is a learning model that starts with project planning and development by producing work as a product that can be presented and published (Patton, 2012). The PjBL model is one of the innovative learning models that have the characteristics of 21st-century education, namely critical thinking skills because it can activate a process that allows students to participate and find experiences that are different from before so that students can reflect opinions critically (Afifah et al., 2019). In addition, this learning model is suitable for use on abstract material such as Human Excretion System material because it can produce products in the form of teaching aids that can provide a direct description of the material being studied. This learning model encourages students to be collaboratively responsible for accessing and managing information in solving problems (Rahmania, 2021).

In addition to the PjBL model, current learning needs to keep up with globalization by integrating Science, Technology, Engineering, and Mathematics (STEM) in building 21st-century skills (Kaleci et al., 2018). STEM is an interdisciplinary approach related to science, technology, engineering, and mathematics that can make students more actively involved in learning and develop an understanding of concepts (Badriyah et al., 2020). The research results of Afifah et al., (2019) also state that the STEM learning approach that integrates the four sciences can logically improve students' thinking skills through the approach's characteristics.

This STEM approach fits the PjBL model (Fitriyani, 2020). Through the PjBL learning model, students will better understand the concept through making products. In contrast, through learning using the STEM approach, the design process will provide direct experience in making products and make students produce their best products (Tipani et al., 2019). The PjBL model combined with STEM can improve conceptual understanding and make students more actively involved in learning (Asri, 2021).

Based on the background above, the writer is interested in conducting research the effect of the PjBL model with a STEM approach on students' critical thinking skills on the material of the Human Excretory System at SMP Negeri 37 Medan. So, the purpose of this study is to determine the effect and much effect of the PjBL model with a STEM approach on students' critical thinking skills on the material of the Human Excretory System at SMP Negeri 37 Medan.

METHOD

The design used in this research is quasi-experimental research. The type of design used is the pretest-posttest control group design. In this design, there are two groups: the experimental and the control groups. These two classes receive the same learning material, namely the Human Excretion System material, but using different learning models. The experimental class was treated using the PjBL-STEM model, while in the control class, the learning process was carried out without using the PjBL-STEM model. The pattern in

this design can be seen in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	O1	X1	O2
Control	O3	X2	O4

Where:

O_1: Pre-test for the experimental class

O_2: Post-test for the experimental class

O_3: Pre-test for the control class

O_4: Post-test for the control class

X_1: Treatment using the PjBL-STEM model

X_2: Treatment without using the PjBL-STEM model

Data collection techniques in this study were in the form of tests and non-tests. The tests in this study were tests of critical thinking skills, while the non-tests in this study were conducted through interviews, observation, and documentation. Data analysis of posttest results was carried out by independent sample t-test using the SPSS program version 26.0. The effect size test that was carried out in this study is intended to determine the effect of the PjBL-STEM model on students' critical thinking skills.

To determine the effect size in the t-test, Cohen's formula is used as follows:

$$d = \frac{\overline{X}t - \overline{X}c}{S_{pooled}}$$

The criteria used to determine the magnitude of the effect of the treatment can be interpreted in Table 2.

Table 2. Interpretation of Effect Sizes

Cohen's d	Information
0-0,20	Weak
0,21-0,50	Enough
0,51-1,00	Currently
> 1,00	Strong

RESULTS AND DISCUSSION

This study aims to determine the effect of PJBL-STEM model on students' critical thinking skills on Human Excretion System material. The experimental and control classes were first given a pre-test in the form of five critical thinking essay questions. After being given treatment in the experimental class, namely learning using the PJBL-STEM model and also in the control class with conventional learning, at the end of the lesson a final test (post-test) was given to determine the effect of the PJBL-STEM model on students' critical thinking skills. Student pre-test and post-test data are shown in Table 3.

Tabel 3. Pretest and Posttest Data on Critical Thinking Skills

Categ.	Data	Class	N	Min Score	Max Score	Mean	Stndrd. Dev
Critical Thinking Skills	Pretest	Control	31	5	35	29.35	11.10
		Experiment		15	50	33.71	10.56
	Posttest	Control		35	70	52.58	9.65
		Experiment		70	90	80.00	7.07

The data in Table 4.1 shows the pretest and posttest scores in the control class and experimental class. From the table it can be seen that the pretest in the control class obtained an average value of 29.35. Then after the treatment in the posttest control class obtained an average value of 52.58.

Based on the research that has been done, the results of the t-test results, it can be seen that t_{count} = 12.761 and t_{table} (df_{60}) = 1.671 with Sig. (2-tailed) = 0,000. Because t_{count} 12.761 > t_{table} 1.671, and the significance value 0,000 < α, with α = 0.05, so H_0 is rejected and H_a is accepted, which means that there is an effect of implementing PJBL-STEM on students' critical thinking skills.

The results of hypothesis testing to see whether there is an effect of the PJBL-STEM model on critical thinking in both classes are shown in Table 4.

Tabel 4. Summary of the Posttest Hypothesis Test of Critical Thinking Skills

Instrument	Class	T count	T table	$\overline{X}$	Sig. *(2 tailed)*	Con.
Critical Thinking Skills	Eksperiment	12.761	1.671	80.00	0.000	H_0 rejected and H_a accepted
	Control			52.58		

In line with Dywan & Airlanda (2020) research, it states that the application of the PJBL-STEM model provides direct practice not just abstract so that through direct learning experiences it will stimulate students' critical thinking skills through the activities in it.

The PJBL-STEM model has a syntax that can support students' critical thinking skills which consists of five processes, namely: reflection, research, discovery, application and communication. The implementation of this research was carried out with 4 meetings for experimental and control classes. In the first meeting, in the experimental class that used the PJBL-STEM model, the sub-material "Structure and Function of the Kidney, Disorders and efforts to maintain kidney health in the Human Excretion System" was taught. The researcher gave an apperception to students by showing an animated video of someone holding back urination. Students are interested in seeing the animated video presented. Students are given the opportunity to be able to formulate basic questions which is one of the indicators of critical thinking skills. This can stimulate the emergence of critical thinking in students in formulating the main points of the problem.

The first phase of the PJBL-STEM model at the first meeting begins with the reflection stage, where at this stage the researcher divides students into 5 study groups consisting of 5-6 students in each group. Researchers invite students to learn together through ppt explanations that are presented regarding the structure and function, disorders and efforts of the human excretion system (kidneys). Then the researcher provides an opportunity for students to answer some questions that arise at the apperception stage at the beginning of learning. This will encourage critical thinking skills on the indicator of providing simple explanations. Students are trained to answer questions using their own thoughts and language, so they are not focused on memorization from reading books. Students who are able to answer questions using their own language will train their ability to think deeply to solve a problem. An attitude that is able to respond to various problems is the activity of someone who can be said to have critical thinking skills. (Glaser, 1941). In this

phase, researchers try to connect students' prior knowledge with what will be learned next. Through the activities in the first phase, students will have curiosity, especially in the process of urine formation. Through this first phase of the PJBL-STEM model, students will be brought into the context of the problem and will inspire students to immediately start investigating (Jauhariyyah et al., 2017). After that, researchers distributed LKPD to each group to continue the next stage of learning.

The second phase of the PJBL-STEM model is research, where in this phase students begin to be oriented to be actively involved in learning in groups. Students are directed to observe activity 1 related to the process of urine formation. Students are directed to understand the work procedures and tools and materials in the planning of making urine formation products in the LKPD. Students are also trained to be able to work together in gathering information from several sources such as books and the internet that support the planning of making these products. This stage is included in the technology category in the STEM aspect because students can utilize technology with the help of the internet in learning activities to build and develop students' basic skills. In line with the opinion of Srigati (2020), that STEM learning integrates science knowledge by utilizing technology for the design process in its implementation. Learning excretion material with the PjBL-STEM model also makes students work independently in groups and encourages increased student activity in the group, so that the knowledge gained is more in-depth (Tipani et al., 2019; Nurbaiti et al., 2016).

Through the STEM-based LKPD that has been distributed, aspects of students' critical thinking skills will also be honed on the indicator of building basic skills. Learners will better understand the integration of science, technology, engineering, and math in human excretion system material. In line with the opinion of Afifah et al., (2019), that the implementation of STEM education provides opportunities for students to understand the importance of the integration of different disciplines and their application in learning. Thus students can improve their critical thinking through the implementation of STEM education.

The third phase in the PJBL-STEM model is discovery, which is the process of bridging research and known information in project preparation. At this stage, it involves STEM aspects in the engineering category because each group begins to collaborate and discuss the product design planning schedule, starting from the division of tasks to bring tools and materials for each group member, calculating the design costs required in making projects and determining the division of costs that must be incurred per individual. The critical thinking skills that appear at this stage are in the indicator of developing strategies and tactics in problem solving, where students must be able to build arguments and design solutions regarding the design of the product they will make (Allanta & Puspita, 2021). In line with this, through the PJBL-STEM model at this stage students are also trained to develop the ability to build a habit of mind from the design process (Jauhariyyah et al., 2017).

After the third phase, the first meeting ended with a closing activity where students reviewed the results of the learning activities that had been carried out in accordance with the learning objectives presented in the initial activity. In this case, the critical thinking skills that emerge are in the indicator of providing further explanation. After information gathering activities through various sources, students began to be able to provide explanations by summarizing the material

they learned today. Researchers provide material enhancements at the end of the lesson and don't forget to remind students to bring the tools and materials they have discussed in their respective groups. Researchers also provide tasks through LKPD that are distributed so that students are more trained to work on questions that stimulate the emergence of critical thinking skills, where in LKPD the questions already contain critical thinking indicators and are combined with STEM aspects. Equipping students with critical thinking skills will make them able to keep up with the development of learning according to the times so that it can increase effectiveness, meaningful learning, and support future careers (Dywan & Airlanda, 2020; Jauhariyyah et al., 2017).

The fourth phase of the PJBL-STEM model, namely application, continued at the second meeting. This stage is the stage of the creation process where students collaboratively carry out projects that have been planned previously. Each group is directed to start working on making products based on the work procedures in the LKPD. Students work together and share tasks during product development so that it doesn't take a long time. STEM aspects in the engineering category are very visible at this stage because students are able to make products through the design process. This also fosters students' critical thinking skills in the sub-indicator of interacting with others. Activities carried out in learning that are more oriented towards the active involvement of students will be able to stimulate students to think critically. The PJBL-STEM model also provides challenges that can improve higher order thinking skills (Afifah et al., 2019). The researcher will continue to monitor the progress of each group's project. Through project making activities, students will better understand the concept of the process of urine formation starting from the first stage of filtration, to the final stage of reabsorption.

Students will also better remember the structure of the kidney organ that plays a role in the process of urine formation because they are directly involved in making it from their tools and materials. The PJBL-STEM model will provide learning experiences to students in real activities. At this stage students are invited to do meaningful learning in understanding a concept and exploring through a project activity, so that students are actively involved in the process (Fitriyani et al., 2020; Srigati, 2020). In this phase, there is also an evaluation process because after making the product, students test the product results according to predetermined conditions, then the results obtained are used to improve the previous step. In this phase, students will learn a broader context where they can connect the subject matter with the integration of STEM fields through the product creation process (Jauhariyyah et al., 2017; Sayekti 2020; Haryadi & Pujiastuti, 2021).

The last phase of the PJBL-STEM model is communication, this final stage students develop communication skills. After obtaining meaningful learning from the process of making products, students present the results of making projects that they have made. In this stage, students will provide information on the findings that have been carried out and then finally draw conclusions (Allanta & Puspita, 2021). Other groups will also respond to the results of the presentation which includes questions and answers, giving rebuttals, and reasons and providing/ completing additional information. The existence of differences of opinion between groups will foster students' critical thinking skills to be able to solve existing problems. Students who have high critical thinking skills will tend to be able to analyze information to

find the truth (Allanta & Puspita, 2021). The researcher guides students to be able to evaluate, reflect and make improvements to the results of group activities in order to equalize perceptions of the product work. In the end, the researcher together with the students concluded the results of the work and provided reinforcement of the material. Student-centered learning activities stimulate students to think critically and increase students' understanding of the concept (Nurbaiti, 2016). The PJBL-STEM model provides opportunities for learners to collaborate to solve a problem (Simatupang & Purnama, 2019) requires critical thinking and analysis (Fitriyani et al., 2020) and supports future careers (Afifah et al., 2019).

Testing the effect of treatment using the Cohen's d Effect Size formula. Based on Cohen's d test, the value of d=3.242, then the results obtained cohen's d value is greater than 1,00 (3.242 > 1,00) and in the interpretation table the value of Cohen's d is classified as high. It can be concluded that the PJBL-STEM learning model has a strong effect on students' critical thinking skills in the experimental class.

The results of the calculation of the effect of the PJBL-STEM model treatment on students' critical thinking skills using the Cohen's d test can be seen in Table 5.

Table 5. The Effect Size Test Results

Instrument	S_{pooled}	*d value*	Category
Critical Thinking Skills	8.459	3.242	Large effect size

Based on the Independent Sample T-Test test that has been conducted by researchers to test the effect of the PJBL-STEM model on students' thinking skills in learning science material on the Excretion System. The results obtained from the Independent Sample T-Test test showed that students in the experimental class taught with the PJBL-STEM model had higher critical thinking skills compared to students in the control class. To find out how much influence the PJBL-STEM model treatment on the experimental class, the researcher conducted a large test of the treatment effect (effect size) which stated that the PJBL-STEM model had a strong influence in improving students' critical thinking skills based on the Cohen's d test with value 3.242.

Based on the Cohen's d test data with a value of 3.242, it shows that there is a strong influence of the treatment with the PJBL-STEM model on the critical thinking skills of students in the experimental class. Based on the opinion of Anwar (2011), the value is included in the high category where 3.242 > 1.00 which shows the strong influence of the PJBL-STEM model on students' critical thinking skills.

Learning activities using LKPD in experimental classes encourage students to continue to stimulate their critical thinking skills through a series of activities in accordance with the five aspects of critical thinking indicators and are also linked to STEM science in it. Through activities with the PJBL-STEM model, students continue to be honed to be able to provide simple explanations in their own language, build basic skills, infer information, and build interactions with the surrounding environment from various activities in the LKPD.

The obstacles faced by researchers in this study were when at the beginning of the meeting where students were less conducive in determining their respective group members. Students tend to want their group members to be their close friends, the distribution of group members is uneven. However, researchers can overcome these

obstacles by motivating students to continue to follow the rules that researchers make. In addition, researchers found obstacles in the form of project work that took a long time, so the project made was represented by a project to make props for the formation of urine in the kidneys and also a poster of efforts to prevent diseases of the excretion system at the end of the meeting. However, students can experiment making projects independently through activities on LKPD on each meeting topic. Despite all the obstacles experienced by researchers, students are very enthusiastic about learning in class with the existence of learning groups and making projects into a product

CONCLUSION

Based on the results of research and discussion, it can be concluded that there is an effect of PJBL-STEM model on students' critical thinking skills in the material of the Human Excretory System in 8th grade class at SMP Negeri 37 Medan with value $t_{count} > t_{table}$ (12.761 > 1.671) using the Independent Sample T-test and the effect of the PJBL-STEM model treatment taught in the experimental class has a strong effect with the results of the cohen's d test = 3.242.

The researcher provides suggestions that the research can be used as inspiration in conducting a useful research activity in the field of education. For the school, researchers hope to provide benefits in developing a meaningful learning model so that it can achieve learning objectives optimally. For future researchers, they should be able to optimize time as well as possible so that project making can be carried out properly and it is also recommended to conduct research on other learning models combined with STEM to disseminate STEM applications that are in accordance with the character of 21st century education

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