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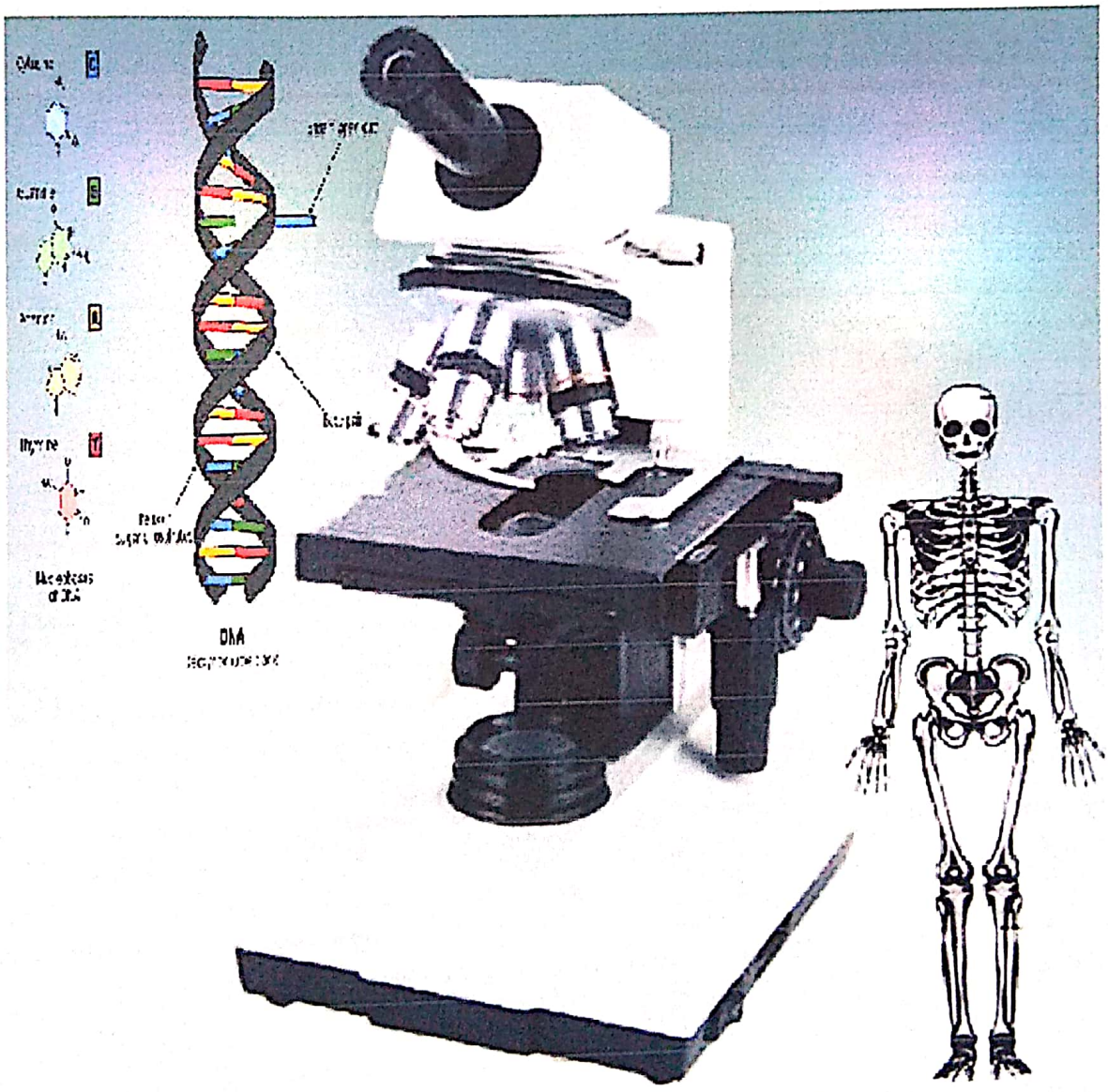

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Project and problem based learning on students' critical thinking skills at cell material

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ABSTRACT

Based on observations when apprenticed at SMAN 7 Pontianak it was known that students' critical thinking skills are still low. Therefore, a variety of learning models are needed to improve students' critical thinking skills. The purpose of this research was to determine the differences and effective learning models in improving students' critical thinking skills between students taught using the project-based learning model and the problem-based learning model. The research method used was a quasi-experiment with a nonequivalent control group design. The data collection techniques used were measurement. The results showed a significant value of the T-test was 0.000<0.05. This means that there are differences in students' critical thinking skills taught using the project-based learning model and problem-based learning. The average value of N-Gain in the project-based learning model was 0.69 (moderate) while the problem-based learning model was 0.58 (moderate), so the project-based learning model is more effective than the problem-based learning model on students' critical thinking skills.

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INTRODUCTION

Critical thinking is a reflective and reasonable reason to decide what to believe or what to do (Wahyuni, 2015). Critical thinking means having the ability to ask clearly and reasoned, prove something accompanied by evidence, try to understand the problem well, use reliable sources and be able to consider a variety of different information to be processed, analyzed, and concluded (Rosana, 2014; Bustami, Syafruddin & Afriani, 2018). Critical thinking skills are more emphasize something that is acceptable to reason and considers all alternatives before making a decision. So,

critical thinking skills are skills that focus on things that are reasonable and reflective, so that they can conclude to believe things and carry out what is decided (Azizah, Jayadinata, & Gusrayani, 2016). Critical thinking allows students to analyze their thoughts in making choices and draw conclusions intelligently (Kurniawati, Wartono, & Diantoro, 2014). critical thinking skills are the basis of the learning process.

The teacher has a very important role in learning. Therefore, teachers are expected to have a good teaching method and can choose appropriate learning methods, so that students have critical thinking skills. Based on observations by researchers at SMAN 7 Pontianak that some students lack understanding and express the meaning of a picture that has been conveyed by the teacher, there is still a lack of students in identifying and concluding an existing problem, there is still a lack of students in appreciating belief in the answers to questions the teacher has proposed. The problem is related to several indicators of critical thinking skills. Another problem in schools is still less its variety of use models. Therefore, need to find a model that can be given to students to improve students' critical thinking skills. One of them is a very appropriate alternative learning model to improve critical thinking skills is the project-based learning model and the problem-based learning model (Anazifa & Djukri, 2017; Amin, Utaya, Bachri, Sumarmi, & Susilo, 2020).

Project-based learning models are learning models that use projects or activities as the core of learning (Handayani, Karyasa, & Suardana, 2015). Project-Based Learning can improve students' critical thinking skills such as arguing, explaining, analyzing, evaluating, and determining what steps should be taken (Insyasiska, Zubaidah, & Susilo, 2015). Project-based learning is learning that allows students to work independently in constructing their learning and culminating in real products (Mahendra, 2017). Project-based learning is innovative learning that emphasizes complex activities to solve problems based on inquiry activities. This is by the learning objectives at school that students can solve problems in daily life (Jagantara, Adnyana, & Widiyanti, 2014; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). This learning model can make students more disciplined, involve students in problem-solving activities, provide opportunities for students to work autonomously in building their learning, and ultimately produce student work products that are valuable, and realistic (Munawaroh, Christijani, & Supriyanto, 2013).

Problem-based learning uses various kinds of intelligence needed to deal with new things and the problems that arise (Wulandari & Surjono, 2013). Problem-based learning is a learning model that uses real-world problems as a context for students to learn about critical thinking and problem-solving skills, as well as to obtain essential knowledge and concepts from the subject matter (Nafiah & Suyanto, 2014). Problem-based learning is a learning model that can be said to be a strategy where students learn through practical problems relating to the real world, students are directed to solve the problems that are being discussed through a series of systematic learning (Dewi & Jatiningsih, 2015). Problem-based learning models affect the ability of students to conceptual problem solving that has implications for the depth of student understanding concepts. Students who have a deep understanding of concepts will be able to form their knowledge (Handayani, et al., 2015). Problem-based learning is a learning model that involves students in solving real-world problems. This model causes motivation and curiosity to increase. The problem-based learning model also becomes a place for students to develop critical thinking and higher thinking skills (Gunantara, Suarjana, & Riastini, 2014).

The material used to measure students' critical thinking skills is cell material using project-based learning and problem based learning models. This cell material is assessed by the teacher as material that requires a higher level of understanding because this material is very related to the material that will be studied next. Besides, cell material is not only taught through theory but the practice is also needed because it requires confirmation and direct explanation by the teacher.

Based on these problems it is necessary to research the project-based learning model and problem based learning on students' critical thinking skills. Both of these learning models can be an option in facilitating biology learning because by applying these two models, students are expected to be able to improve critical thinking skills such as providing interpretations or able to classify existing problems, analyze, make conclusions, evaluate, provide an explanation of statements and opinions received, and practice self-confidence in dealing with existing problems.

RESEARCH METHODS

Research Design

The research method used was a quasi-experimental research with the nonequivalent control group design. The nonequivalent control group design can be seen in Table 1.

Table 1. Design nonequivalent control group design

Class	*Pretest*	Treatment	*Postest*
A1	O1	X1	O2
A2	O3	X2	O4

Note:
A1 : Experiment class 1
A2 : Experimental class 2
O1 : Pretest the experimental class 1
O3 : Pretest the experimental class 2
O2 : Posttest experimental class 1
O4 : Posttest experimental class 2
X1 : The experimental class 1 treatment uses the project-based learning model
X2 : The experimental class 2 treatment uses the problem-based learning model

Population and Samples

The population in this study were students of class XI MIPA in Pontianak 7 Public High School in the academic year 2019/2020. The sample in this research used 2 classes. Before determining the research sample, the variance homogeneity test is carried out using the Bartlett test. Bartlett test results obtained overall class population results are homogeneous. Sampling in this study was conducted using a simple random sampling technique. Class XI MIPA 1 students totaling 34 students were used as experimental class II with problem-based learning models and class XI MIPA 3 students totaling 34 students were used as experimental class I with project-based learning models.

Instrument

The instrument in this research was a test item related to critical thinking skills. This test is given to know and measure students' critical thinking skills. The critical thinking skills test in this research was a two-tier multiple-choice with each question criterion containing 15 critical indicators of students' critical thinking skills.

Procedures

The research procedure used in this study consisted of four stages. The first stage, the preparatory stage which consists of designing learning tools used in the form of learning implementation plans and student worksheets, preparing research instruments in the form of critical thinking skills test questions, validating learning devices and research instruments (pretest

and posttest questions), revise the learning tools and research instruments if there are improvements, test the pretest and posttest, determine the reliability of the instrument tested about the problem, the instrument is declared unreliable, the repair process will be carried out until the instrument is declared reliable, and determine the experimental class I and experimental class II; the second stage, the implementation stage by conducting pretest activities in experimental class I and experiment II, providing treatment by implementing learning using the project based learning and problem based learning models; third stage, posttest stage by giving posttest questions to see the biology students' critical thinking skills; the fourth stage, the stage of analyzing the data obtained by comparing the results of students 'critical thinking skills between experimental class I and experimental class II with the aim of knowing differences in students' critical thinking skills, making conclusions as answers to research problems, and compiling research reports.

Data Analysis

The data analysis technique used in this research was to determine the value of the pretest and posttest. The pretest and posttest results of the two students of the experimental class were given scoring criteria according to (Wulandari, Yamtinah, & Saputro, 2015) which can be seen in Table 2. The pretest and posttest results of students were then converted to scores with the criteria of students' critical thinking skills according to Majid, (2014) and Husen, Indriwati, & Lestari, (2017) which can be seen in Table 3.

Table 2. Scoring the two-tier test model

Students answers		Score
First Tier	Second Tier	
True	True	3
True	False	2
False	True	1
Not Answering	Not Answering	0

Table 3. Criteria for students' critical thinking skills

Score	Category
85.00 - 100.00	Very high
70.00 - 84.99	High
55.00 - 69.99	Medium
40.00 - 54.99	Low
0.00 - 39.99	Very low

Measurement of differences in critical thinking skills can be analyzed using gain values. Before testing the hypothesis, the prerequisite test is the normality test and homogeneity test. Hypothesis testing uses a T-test with a significance level of 5%. Determine the most effective method for critical thinking skills using project-based learning and problem based learning models calculated using the N-Gain formula (Fayakun & Joko, 2015).

RESULTS

The results of research related to critical thinking skills data were obtained after learning using the project-based learning model and the problem-based learning model. Based on the results of research that has been done, it is obtained the average gain value of the two classes can be seen in (Table 4).

Table 4. Average and gain value of the project and problem-based learning models

Class	Average value		Gain
	Pretest	Posttest	
Project-based learning	33.92	79.48	45.56
Problem-based learning	33.53	72.29	38.76

Based on Table 4 it appears that there are differences in students' critical thinking skills in the experimental class I using the project-based learning model and the experimental class II using the problem-based learning model. The gain value in the experimental class I using the project-based learning model was higher than the experimental class II using the problem-based learning model.

It is known that the significant value of gain in the class using the project-based learning model is 0.611> 0.05 and the significant value of the gain in the class using the problem-based learning model is 0.142> 0.05. The results of the normality test for both data are more than 0.05, the data are normally distributed (Table 5). Because the data is normally distributed, it is followed by a homogeneity test. Obtained a significant value was 0.785. The significance value was 0.785> 0.05 then the data is said to be homogeneous (Table 6). After the data is normally distributed and homogeneous, it is continued with the hypothesis test to find out the differences in the results of the T-test. The T-test is a parametric test used to test how far the influence of the independent variables used by researchers in explaining the dependent variable.

Table 5. Normality test results

Class	Shapiro Wilk		
	Statistics	df	Sig.
Project based learning	0.975	34	0.611
Problem based learning	0.952	34	0.142

Table 6. Homogeneity test results

Levene Statistics	dfI	df2	Sig.
0.075	I	66	0.785

Table 7. T-test data results

Levene's test for equality of variances		T-test for equality of means		
F	Sig.	t	df	Sig. (2-tailed)
0.075	0.785	4.662	66	0.000
		4.662	65.500	0.000

Based on Table 7 the T-test results obtained are equal to 0.000 <0.05. Based on the hypothesis, there are differences in the Project-Based Learning learning model and the problem-based learning model for critical thinking skills. T-test results are smaller than 0.05, so there are differences in the project-based learning model and problem based learning on students' critical thinking skills.

Based on the T-test that has been done, it can be seen that there are significant differences in students 'critical thinking skills (0.000 <0.05) which states that there are differences in the project-based learning and problem-based learning models of students' critical thinking skills. Percentage of difference in project-based learning and problem based learning models on students' critical thinking skills using N-Gain values.

Based on the calculation of the average value of N-Gain in the experimental class, I using the project-based learning model is 0.69 and the experimental class II using the problem-based learning model is 0.58. It can be seen that both learning models fall into the medium category. This proves that the value of N-Gain between the project-based learning model has an average value higher than the problem-based learning model. Based on these indicators, the project-based learning model is more effective than the problem-based learning model on students' critical thinking skills.

Table 8. Indicators percentage of students' critical thinking with project-based learning

No	Indicators of critical thinking skills	Pretest		Posttest	
		Percentage (%)	Category	Percentage (%)	Category
1	Interpretation	35.94	Very low	79.41	High
2	Analysis	37.58	Very low	76.14	High
3	Inference	29.08	Very low	80.06	High
4	Evaluation	25.00	Very low	80.88	High
5	Explanation	45.09	Low	82.35	High
6	Self-regulation	30.09	Very low	79.41	High
	Average	33.92	Very low	79.48	High

Data on the results of the pretest and posttest on critical thinking skills per indicator in the project-based learning model can be seen in Table 8. Based on Table 8 shows the average percentage of indicators of students' critical thinking skills based on the pre-test and post-test scores. In the experimental class, I using the project-based learning model to increase after being given treatment. Data on the results of the pretest and posttest about the critical thinking skills per indicator in the problem-based learning model can be seen in Table 9.

Table 9. Indicators percentage of students' critical thinking with the problem-based learning

No	Indicators of critical thinking skills	Pretest		Posttest	
		Percentage (%)	Category	Percentage (%)	Category
1	Interpretation	37.25	Very low	74.50	High
2	Analysis	38.56	Very low	71.24	High
3	Inference	24.83	Very low	70.58	High
4	Evaluation	27.45	Very low	73.52	High
5	Explanation	41.66	Low	76.96	High
6	Self-regulation	31.37	Very low	67.15	Medium
	Average	33.53	Very low	72.29	High

Based on Table 9 shows the average percentage of indicators of students' critical thinking skills based on the pre-test and post-test scores. In the experimental class II using the problem-based learning model increased after being given treatment.

DISCUSSION

Based on the results of research that have been done regarding the differences in the project-based learning model and the problem-based learning model on critical thinking skills on cell material carried out at SMA Negeri 7 Pontianak in experimental class I and experiment II could be obtained results in the experimental class I with an average gain value was 45.56 and experimental class II with an average gain value was 38.76. It can be said that the two learning models experience differences.

The first indicator of critical thinking skills is interpretation. The ability of students in this interpretation of the project-based learning model was 79.41 and higher than the problem-based learning model was 74.50. Interpretation is an indicator to be able to understand and express the meanings of various experiences, judgments, and beliefs (Facione, 2015). Students who are in this category show an increase with the provision of project-based learning models and problem-based learning which proves the ability to describe problems and complete a given project. (Sandoval & Millwood, 2015) states that in the aspect of interpretation in students can classify existing problems.

The second indicator of critical thinking skills is analysis. The skills of students to analyze the project-based learning model was 76.14 and included in the high category compared to the problem-based learning model was 71.24. The analysis is an indicator to identify inferential relationships that are intended and real in a question, concept, description, or other forms of representation to express trust, judgment, experience, reason, information, and opinions (Facione, 2015). The emergence of aspects of analysis in the delivery of PJBL learning models and PBL has increased. Students in this category can demonstrate the ability to understand and express meaning or from the learning process that has been given, can distinguish which eukaryotic cells and prokaryotic cells and analyze the conclusions from the definition of cells. In this aspect of analysis, students can solve a given problem that is directly related to real-life associated with cell matter and making a project related to cell material that is making the structure of animal cells and plant cells.

The third indicator of critical thinking skills is inference or conclusion. The skills of students to conclude the PBL learning model was 80.06 falls into the high category compared to the PBL learning model was 70.58. Inference or conclusion can be interpreted as an indicator to be able to recognize the elements needed to draw a conclusion that makes sense, to consider relevant information and reduce the consequences that flow from data, questions, principles, evidence, judgment, beliefs, opinions, concepts, description, and others in the form of representation (Facione, 2015). In this category, students can understand and express the meaning or meaning of a given learning experience and can group the meanings or meanings of their knowledge.

The fourth indicator of critical thinking skills is evaluation. The skills of students in evaluation indicators on the PjBl learning model is 80.88 and included in the high category compared to the PBL learning model was 73.52. Evaluation as meaning to assess the credibility of a statement or other representation that is a description of a person's perception, experience, situation, judgment, belief, or opinion (Facione, 2015). In this category, students can demonstrate the ability to understand the meaning of the learning experience provided and the discussion with group members to solve problems and complete a project with the material that has been given.

The fifth indicator of critical thinking skills is an explanation. In this explanatory indicator category, the PjBL learning model was 82.35 and included in the high category compared to the PBL learning model was 76.96. Explanation or can explain statements or opinions that have been expressed in a way that makes sense and is coherent as a result of one's reasoning (Facione, 2015). In this category, students can demonstrate the ability of the learning experience given as can show the specific results of cell discovery. In line with the suitability of the stages of the PjBL learning model and PBL provided such as determining the project to be made, investigation, and project presentation.

The sixth indicator of critical thinking skills is self-regulation or self-confidence. The skills of students to find their confidence in the PBL learning model was 79.41 higher than the PBL learning model was 67.15. Self-regulation or self-confidence means consciously able to regulate his existence in dealing with existing problems (Facione, 2015). Students in this category demonstrate the ability to describe problems based on real-life according to the material provided. By giving

these two learning models can train students in finding their confidence by working with group members in solving problem cases and solving projects based on the material provided.

The material used in this research is cell material. In this material, the use of the PjBL learning model has a value was 79.48 included in the high category of the PBL learning model was 72.29, this PjBL learning model in the learning process takes place students are more active to appreciate themselves through making projects. This model also makes students have high cooperation because of the question and answer process among members of the group than in the process of making this project also makes students happy to complete the given project.

Project-based learning has staged such as preparation, assignment or determining topics, planning activities, investigating and presenting, finishing, monitoring, or evaluating. In the stages of the learning process match the material used, namely cell material, making projects contained in cell material is the manufacture of animal cell structures and plant cells. The stages of this learning model can increase because the learning process is fun for students and the project work is completed well.

The results of the research presented above indicate that there is a significant increase in the use of project-based learning models for students' critical thinking skills. Students' critical thinking skills can be improved because in the learning syntax there are student activities that train them to think. Along with the thought process that is trained and honed, students are increasingly critical thinking skills. Students who increase their ability to solve problems logically and reflectively are very beneficial when they encounter problems. Plus cooperative learning makes students discuss each problem together. This means the teacher has been able to create a good learning environment. The existing learning environment in the project-based learning model as expected is authentic. Learners will find it easier to learn in environments such as authentic learning environments and can be realized by the project-based learning model (Sularmi, Utomo, & Ruja, 2018).

Learning by increasing critical thinking skills can be done by educators learning using constructivist learning strategies that have the potential to empower critical thinking skills, such as learning this project. Through learning in improving critical thinking skills students are expected to be able to integrate abilities such as observation, analysis, judgment reasoning, and decision making. Implementation can be done by building a classroom atmosphere that can respect students' thinking and analysis (Pratama & Prastyaningrum, 2016). The use of the problem-based learning model can also improve students' critical thinking skills from before and after giving a learning model but is not higher than the project-based learning model. The problem-based learning model makes students active in constructing their knowledge through discussions and problems based on real problems. This encourages critical thinking skills maximally and also the problem-based learning model can foster the development of a curious attitude or want to know further, and how to think objectively, independently, critically, and analytically both individually and in groups (Amin, 2017).

Student involvement in problem-solving can build their knowledge as well as a grouping in learning can facilitate students to collaborate, exchange ideas, teach each other, and can solve problems in many ways because it allows the emergence of a variety of different thoughts. The presentation process also made students better understand the existing problems so that their appearance in front of the class did not disappoint. Whereas when students discuss with students in their groups, students are practicing to express ideas smoothly, think broadly, and be able to review problems from a variety of different perspectives (Utomo, Wahyuni, & Hariyadi, 2014).

Project-based learning and problem-based learning models can both enhance students' critical thinking skills because it can contribute to dealing with a problem such as producing a product and solving real problems. However, the project-based learning model has higher critical thinking skills than the problem-based learning model because in the project-based learning model there is a

student activity in the learning syntax that trains them to think. Along with the thought process that is trained and honed, students are increasingly critical thinking skills. Students who increase their ability to solve problems logically and reflectively are very beneficial when they encounter problems. Coupled with cooperative learning makes students discuss each problem together (Sularmi, et al., 2018). But for the problem-based learning model which is the topic or theme of the problem is less than the core material explained because the topic or theme is given more in-depth in the sub material presented. Learning with the problem-based learning model requires setting appropriate learning time for each point of the problem. But this was not done well. As for other factors such as students are also not familiar with problem-solving activities so it requires more time to assist in problem-solving activities.

After applying both the project-based learning model and the problem-based learning model to students' critical thinking skills, based on the results obtained, there are differences in critical thinking skills between students taught using the project-based learning model and students taught using the problem-based learning model on students' critical thinking skills. The difference in critical thinking skills can be seen from the stages of the learning process that uses projects and solving problems as part of the stages of the learning process. The final result of the critical thinking skills in the provision of the project-based learning model is higher than the provision of the problem-based learning model because the stages of the project-based learning model are more fun when carrying out the learning process than students are also enthusiastic when working on a given project.

Based on the results of research on the effectiveness of the project-based learning model and problem-based learning model on the critical thinking skills of students in the experimental class I cell material and the experimental class II which was carried out at SMA Negeri 7 Pontianak. Measured using N-Gain values, the average N-Gain in the project-based learning model was 0.69 and the problem-based learning model was 0.58. This proves that from the N-Gain value between the project-based learning model has an average value higher than the problem-based learning model, it can be said that the project-based learning model is more effective than the problem-based learning model.

The project-based learning can improve students' critical thinking as in the manufacture of student projects can be a lot more information to train critical thinking skills of students and then based on the results of the study (Ledward & Hirata, 2011) that study of the project also makes students are focused in for the resolution of the project given, encourage students to live it with hard work, concepts, and principles the core or main of the material presented. Projects also for students must be made in such a way that there is a relationship between activities and conceptual knowledge that is expected to develop into a wider and deeper (Insyasiska et al., 2015). In the learning provided by the project-based learning model by the results of the study (Pratama & Prastyaningrum, 2016) states project-based learning provides new experience and knowledge for students because indirectly learning to be a scientist, taking scientific action in implementing a project that is, starting to formulate problems, determine procedures, determine the tools and materials needed, conduct investigations, design and create products, present or communicate products as a result of the investigation process, and conduct group discussions.

Learning with the project-based learning strategy teaches students to be active and critical thinking independently in seeking real-world problem solving based on the tasks given in learning. Students conduct an investigation and analysis of the problem at issue and deliver the results of their investigation in the form of work. These activities lead students to plan, organize themselves, and evaluate the results of their work (Khikmah, 2015). The project-based learning model can get students accustomed to critical thinking and creatively in facing the problems given in the form of projects. Every aspect of observation in project-based learning turns out to have good criteria for

most students who learn by applying this model. students are motivated to do the project when they hear the instructions given by the teacher regarding the project they will be working on. Students who are enthusiastic about what they learn will tend to dig deeper and develop the learning. Students will continue to master and remember rather than forgetting all the knowledge that has been learned in theory, student's application is immediately known through the project (Yance, Ramli, & Mufit, 2013).

Project-based learning in addition to being more effective than the problem-based learning model can also improve students' critical thinking skills, one of which is inseparable from the seriousness of the teacher implementing the steps of the learning model strictly, in the sense that the teacher tries to follow each stage of the project-based learning model used as a reference. During the spelling of the project, students are required to play an active role in various activities. Students can directly combine or associate elements of knowledge and skills (soft skills) in learning that is knowledge and skills to plan an activity, problem-solving, and communication the results of activities or products, in addition to students mastering the content of a subject. Students gain experience of various learning experiences through the use of process skills development and scientific attitudes (Jagantara et al., 2014).

The implementation of the stages of the learning process by using the project-based learning model with the project being carried out, namely the structure of animal cells and plant cells. Stages make students able to put himself in the learning process by using the project as put itself to solve the problems given in the execution of the project make students capable of achieving indicators of the critical thinking skills and including the last indicator that self-regulation that means students are consciously able to regulate their existence in dealing with existing problems (Facione, 2015). Proper implementation of each stage of the learning process by using the project-based learning model fulfills all the indicators of critical thinking skills that make the project-based learning model more effective than the problem-based learning model.

CONCLUSION

Based on the results of research that has been done, it can be concluded that there are differences in students' critical thinking skills between the project-based learning model and the problem-based learning model on cell material in the XI MIPA class of SMA Negeri 7 Pontianak. The calculation of the T-test with a significance level was 0.000<0.05. The average N-Gain critical thinking skills using the project-based learning model was 0.69 and the average N-Gain using the problem-based learning model was 0.58. The average N-Gain value of the two learning models is in the medium category. It was concluded that the project-based learning model has a higher N-Gain value than the problem-based learning model, so it can be said that the project-based learning model is more effectively used to measure critical thinking skills.

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