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Effectiveness of Project Based Learning Model on Collaborative Ability and Critical Thinking of Senior High School Students

Ahmad Slamet Riyadi✉, Siti Alimah, Sigit Saptono

Universitas Negeri Semarang, Indonesia

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Abstract

In this 21st century educational, students are required to be able to have collaborative competence and critical thinking. So that, the school should be able to prepare students with such competences. This is an increasingly competitive challenge in the world of education. The research aims to analyse the effectiveness of PjBL learning models on the collaborative ability and critical thinking of senior high school students on subject of Structure, Way of Life and Role of Bacteria in Life. The method in this research was experimental research with Pre-Experimental design. The research was conducted at SMA Negeri 13 Semarang and MA Nurussalam Semarang with a total of 45 students. We used observation sheets and tests as the instrument. The observation sheet was used to measure collaborative ability while test was used to measure critical thinking skills. The data analysis techniques used standard of criteria and N-gain. Standard of criteria to measure collaborative ability while N-gain to measure increased critical thinking ability. The results of the research obtained (1) The average percentage of the collaborative ability score of class X IPA 2 SMA Negeri 13 Semarang is 71.6% while the class X IPA MA Nurussalam is 71.0%; (2) in the first test, the average percentage of critical thinking ability of class X IPA 2 SMA Negeri 13 Semarang is 62.9% while the class X IPA MA Nurussalam is 78.3%. In the second test, the average percentage of the critical thinking ability score of class X IPA 2 SMA Negeri 13 Semarang is 75.1% while the class X IPA MA Nurussalam is 80.0%. Both classes experienced an increase in the average percentage score of critical thinking abilities. The class X IPA 2 SMA Negeri 13 Semarang has increased by 12.2% while X IPA MA Nurussalam has an increase of 1.7%. Based on the research results it can be concluded that the implementation of PjBL learning model is effective on improving collaborative ability and critical thinking of students in SMA Negeri 13 Semarang and MA Nurussalam Semarang

✉ correspondence :
Postgraduate Universitas Negeri Semarang
Jalan Kelud Utara III No.37, Kota Semarang, Indonesia 50237
E-mail: el_firman.new2014@gmail.com

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INTRODUCTION

In this 21st century, science and technology are growing rapidly. Students are also required to have a collaborative ability mastery competence and critical thinking. This is a challenge especially in the increasingly competitive educational world.

Collaboration is to learn to design and cooperation, consider different perspectives and participate in discussions of certain topics by contributing, listening and supporting others (Greenstein, 2012). Collaboration as a result of learning important to investigate effective strategies in teaching and assessing a skill (Lai et al., 2017). Based on the opinions of Anantyarta & Sari (2017) and Lai et al. (2017) that collaborative indicators include students being able to contribute to the group, to help each other member of the group, be flexible to the opinions All members, can respect individual, differences, take responsibility and accomplish their duties on time.

Critical thinking is a interpretation of information and draws conclusions based on the best analysis (Roekel, 2016). Miri et al. (2007) said that critical thinking is conceptualized as an operative example of high-level thinking that can be accounted for due to reliable test and validation processes. Rifqiyana & Susilo (2016) explained that the indicators of the ability of critical thinking includes the student is able to: (1) analyze the arguments; (2) consider whether the source of information can be trusted or not; (3) determine the outcome of consideration; (4) define terms and consider definitions; and (5) determine the actions taken.

National education aims to develop the potential of learners to become human beings who believe and fear to God Almighty, character noble, healthy, knowledgeable, capable, creative, independent, and become a democratic citizen and Responsible (Depdiknas, 2003). Therefore, curriculum 2013 in addition to being a solution to answer the dynamics of the 21st century is also a curriculum designed to realize the purpose of national education in Indonesia.

Curriculum Development 2013 includes approaches, strategies, models, methods, and new learning techniques (Musfiqon & Nurdyansyah, 2015). The 2013 curriculum apply a scientific approach with some alternative learning models one of which is Project Based Learning (PjBL). The PjBL learning model or often called Project-based learning is a learning model that provides a straightforward and real experience to enrich students understanding of technical theories and concepts (Sababha et al., 2016). In previous studies, the PjBL learning model could enhance student creativity (Cira et al., 2015). In other research, PjBL's learning models can also improve student science process skills as well as improve student achievement (Citradevi et al., 2017). The PjBL learning model is also a model that has complex functions in improving the cognitive, affective and psychomotor skills of students. Furthermore, research into the effectiveness of PjBL learning models to student psychomotor skills is also indispensable.

Preliminary studies conducted at 6 SMA schools in Semarang, namely SMA Negeri 13 Semarang, SMA Bina Nusantara, SMA Muhammadiyah 2 Semarang, MA Uswatun Hasanah, MA NU Nurul Huda and MA Nurussalam Semarang. The preliminary study was done on the grounds that the schools were located on the outskirts of Semarang and the average of their students came from the lower middle economy. Based on preliminary studies in these high schools, it turns out that not many schools have implemented the PjBL learning model because it requires a lot of time, money, and adequate equipment. For that, researcher will conduct research on the effectiveness of the PjBL learning model to collaborative ability and critical thinking at SMA Negeri 13 Semarang and MA Nurussalam Semarang. The research implementation of both schools has reason to see portraits of the implementation of PjBL learning models in schools that have different accreditation status and from different ministries.

METHODS

The population in this research is the students of class X SMA Negeri 13 Semarang and MA Nurussalam Semarang school year 2018/2019. The sampling techniques in this research were conducted with the Purposive Sampling technique. At SMA Negeri 13 Semarang There are 4 classes of X that be taught by 2 different biological teachers. On the recommendation of the deputy principal, researcher were asked to take research in the class X IPA 2 as a sample. In class X MA Nurussalam Semarang only consist of 1 class and 1 teacher then only the class that is used as the research sample. Both classes are experimental classes.

The variables in this research consist of free variables and bound variables. The independent variables in this research are Project Based Learning (PjBL) learning models. The dependent variable in the study are the collaborative ability and critical thinking of students at SMA Negeri 13 Semarang and MA Nurussalam Semarang.

The design of research used by researcher is a design research model Pre-Experimental Designs. This Pre-Experimental Designs model uses the One-Shot Case Study form. Where in the design of this research, there is a group given the treatment and subsequently observed the results. This design can be seen in Table 1.

Table 1. Design research

Group	Treatment	Observation
E_A	X_A	O_A
E_B	X_B	O_B

Source: (Sugiyono, 2016)

Information:

E_A : Experimental group at SMA Negeri 13 Semarang

E_B : Experimental group at MA Nurussalam Semarang

X_A : Treatment given to experimentation group at SMA Negeri 13 Semarang

X_B : Treatment given to experimentation group at MA Nurussalam Semarang

O_A : Observation of experimental group at SMA Negeri 13 Semarang

O_B : Observation of experimental group at MA Nurussalam Semarang

The data collection techniques used in this research include: expert validation, observation techniques, tests techniques and measurements. Expert validation is used to get data on expert assessments on learning devices. This observation technique uses a observation sheet with the intention of observing the research object directly and noting the symptoms seen in the research object. The test technique is conducted on students to determine the students ' critical thinking ability in biological learning. The test instrument used for the test of questions uses biology essay questions, amounting to 20 questions essay of critical thinking . The trial of essay question is used to determine the validity, reliability, level of difficulty and different power of essay questions. The measurement in question is the provision of scores on the results of observations of collaborative abilities and the results of tests of students critical thinking skills given to the experimental class.

The instruments used to retrieve data are observation sheets and test sheets. Observation sheet used in this research is a closed observation sheet. A closed observation sheet is used to see the implementation of the lesson plan that has been designed. Observation sheets are arranged in the form of a checklist based on the components contained in the lesson plan. In addition to the observation sheet on the implementation of the lesson plan, there is also an observation sheet to observe student activities, namely on aspects of collaborative ability . The test instrument used used biological essay questions , amounting to 5 essay questions on critical thinking at the beginning and end of the research. This essay test is used to determine the level and know each indicator of students critical thinking skills.

The data analysis technique used in this study is qualitative descriptive data analysis. By using this technique, the researcher wants to show the facts or symptoms that appear in each application of the PjBL learning model to the collaborative abilities and critical thinking of

students. Data analysis was performed on collaborative observation sheets using standard of criteria and critical thinking test sheets using N-gain.

Collaborative Ability Observation Sheet Analysis

a. The results of qualitative data are in the form of observations of students' collaborative abilities during the learning process. After being scored, the data will be changed in the form of a percentage using the following formula.

$$\text{Percentage (\%)} = \frac{\text{Amount of indicators achieved}}{\text{Amount of indicators}} x\ 100\ \%$$

b. The percentages obtained are then interpreted in the form of sentences such as those listed in Table 2.

Table 2. Interpretation of the percentage of collaborative ability observation sheets

Percentage (%)	Category
> 79-100	Very high
> 65-79	High
> 55-65	Medium
> 39-55	Low
0-39	Very low

c. After the data is interpreted based on the guidelines for percentage of observation sheets, then analyzed and concluded.

Data Analysis of Test Sheet

Tests are used to test the ability of critical thinking in the form of test essays . Interpretation of critical thinking based on indicators from every aspect. Furthermore, the data will be processed as follows.

a. Student answer data were given a score in accordance with predetermined criteria, namely scores 1 through 4.
b. The raw scores are changed in the form of the final test scores using the formula.

$$\text{The value of critical thinking} = \frac{\text{Amount of scores achieved}}{\text{Maximum scor}} \text{x } 100$$

c. Interpret the final score of students critical thinking scores by looking at the categories in Table 3.

Table 3. Determination of the level of critical thinking

Test scores	Ability
Test score ≥ 80	Very high
60 ≥ Test score <80	High
40 ≥ Test score <60	Medium
20 ≥ Test score <40	Low
Test score <20	Very low

d. After the data is interpreted based on the guidelines for scoring, it is then analyzed and concluded.
e. Furthermore, to determine the increase in students' critical thinking skills used the gain index value formula developed by Hake (Modification: Evawani et al., 2013).

$$\text{Gain Index} = \frac{\text{Final test score} - \text{Initial test score}}{\text{Maximum value} - \text{Initial test score}}$$

f. The gain index which is obtained then interpreted with the categories based on Table 4.

Table 4. Categories of gain indexes according to hake

Value Range	Category
G> 0.7	High
0.3 <G <0.7	Medium
G ≤ 0.3	Low

(Modifications: Evawani et al., 2013)

RESULTS AND DISCUSSION

The research of effectiveness of the PjBL learning model to collaborative skills and critical thinking was carried out from 27 October 2018 to 6 April 2019. This research was conducted in two schools, namely SMA Negeri 13 Semarang and MA Nurussalam Semarang. The class used as a place of research at SMA Negeri 13 Semarang is class X IPA 2 while at MA Nurussalam is in class X IPA.

First, the learning process uses the PjBL learning model in Class X IPA 2 of SMA Negeri 13 Semarang. Learning here consists of three meetings. Each meeting consists of 3 lesson hours . In each meeting there are 3 activities

namely introduction, content and closing. At the first meeting the teacher conditions the class, greetings, conveys the learning objectives, divides class X IPA 2 into 6 groups and each group consists of 6 people. After being divided into groups, the teacher conveys the PjBL learning system. The first phase of the PjBL is to determine the fundamental questions after playing a bacterial video and a brief description of the bacteria. Each student is asked to make a question related to bacteria then discuss with the group. The questions are directed at a project that will later be useful as a learning medium. The second phase of the PjBL is designing project planning. Students are directed to be able to decide about what products will be made later and prepare what is needed in making a product, then the first test is held.

At the second meeting, the teacher conditions the class, greetings and asks again the extent of preparation to collect project data. The third phase is to set a schedule. The teacher helps students determine the project schedule and develop alternative steps if the schedule is not on time. The fourth phase is monitoring students and project progress. The teacher monitors the project of each group of students. If the student project is not completed, it can be continued at home.

At the third meeting, the teacher conditions the class, greetings and makes sure the student project is finished. The fifth phase is testing the results. Each group of students presented the results of the project followed by a discussion. After the six group discussions are over, the teacher gives feedback on the abilities achieved by students. The sixth phase is evaluating experience. Alternately, each group of students is asked to reflect on the project that has been made and tell the difficulties and obstacles faced. After that the teacher gives responses and solutions to the problems faced by each group, for improvement at the next meeting. Then a second test is performed.

Second, the learning process uses the PjBL learning model in class X MA Nurussalam Semarang. The learning here consists of three meetings. Each meeting consists of 3 lesson hours . In each meeting there are 3 activities namely introduction, content and closing. At the first meeting the teacher conditions the class, greetings, conveys the learning objectives, divides class X IPA into 3 groups and each group consists of 3 people. After being divided into groups, the teacher conveys the PjBL learning system. The first phase of the PjBL is to determine the fundamental questions after playing a bacterial video and a brief description of the bacteria. Each student is asked to make a question related to bacteria then discuss with the group. The questions are directed at a project that will later be useful as a learning medium. The second phase of the PjBL is designing project planning. Students are directed to be able to decide about what products will be made and prepare what is needed in making a product, then the first test is held.

At the second meeting, the teacher conditions the class, greetings and asks again the extent of preparation to collect project data. The third phase is to set a schedule. The teacher helps students determine the project schedule and develop alternative steps if the schedule is not on time. The fourth phase is monitoring students and project progress. The teacher monitors the project of each group of students. If the student project is not completed, it can be continued at home.

At the third meeting, the teacher conditions the class, greetings and makes sure the student project is finished. The fifth phase is testing the results. Each group of students presented the results of the project followed by a discussion. After the three group discussions have finished, the teacher gives feedback on the abilities achieved by students. The sixth phase is evaluating experience. Alternately, each group of students is asked to reflect on the project that has been made and tell the difficulties and obstacles faced. After that the teacher provides responses and solutions to the problems faced by each group, in order to improve at the next meeting. Then a second test is performed.

The application of the PjBL learning model is said to be effective against the collaborative ability of high school students if

the average score obtained is in the range of 65-100%. Based on the research data retrieval obtained collaborative ability data in the two schools as shown in Table 5.

Table 5. Data on collaborative abilities of senior high school students

Indicator of collaborative ability	Percentage score			
	SMA Negeri 13 Semarang		MA Nurussalam	
	XIPA2	Information	XIPA	Information
Contributing to groups	75.0	High	70.4	High
Be helpful to fellow group members	60.2	Medium	55.6	Medium
Being busy spots the opinions of all members	73.1	High	81.5	Very High
Can respect individual differences	94.4	Very High	81.5	Very High
To be responsible	63.9	Medium	70.4	High
Completing tasks on time	63.0	Medium	66.7	High
Percentage average	71.6	High	71.0	High

In this research, both classes of research have an average of a high percentage of collaborative indicator categories. The average percentage score of collaborative ability class X IPA 2 of SMA Negeri 13 Semarang is 71.6% and the average percentage score of collaborative ability class X IPA MA Nurussalam is 71.0%. The highest indicators of collaborative ability that can be achieved in class X IPA 2 of SMA Negeri 13 Semarang is can respect individual differences . This indicator stands out because students of class X IPA 2 of SMA Negeri 13 Semarang are accustomed to getting along with diverse social environments so as to foster mutual respect for differences. The lowest collaborative indicator is to help fellow group members . The indicator is low because some students of class X IPA 2 of SMA Negeri 13 Semarang live in housing that is less closely tightly to the social conditions of the community that mutual cooperation and help each other. In class X IPA MA Nurussalam, the highest indicator of collaborative ability is can be achieved is being flexible towards the opinions of all members and being able to respect individual differences. The two indicators are interrelated. The indicator value is high because most of the students in class X IPA MA Nurussalam have a strong Islamic background. However there are still shortcomings, namely the indicator of being helpful to fellow group members is still low . This indicator is low due to the geographical influence students homes close to the factory, and the lack of social interaction with the community.

The application of the PjBL learning model is said to be effective against senior high school students critical thinking skills if the average score obtained is in the range of 60-100. Based on research data retrieval obtained data on critical thinking skills in both schools in two times as shown in Table 6.

Table 6. Data on critical thinking skills of senior high school students

Indicators of critical thinking skills	Percentage score of the first test result				Percentage score of the second test result			
	SMA Negeri 13 Semarang		MA Nurussalam		SMA Negeri 13 Semarang		MA Nurussalam	
	XIPA2	Info	XIPA	Info	XIPA2	Info	XIPA	Info
Analyzing arguments	31	Low	78	High	66	High	86	Very High
Consider whether the source of information can be trusted or not	59	Medium	72	High	66	High	83	Very High
Determine the results of	39	Low	75	High	83	Very	97	Very

consideration						High		High
Define the term and consider a definition	91	Very High	92	Very High	78	High	83	Very High
Determine the actions taken	95	Very High	75	High	82	Very High	50	Medium
Percentage average	62.9	High	78.3	High	75.1	High	80.0	Very High
Percentage of completeness	80.6		100		77.8		100	

In the first test of this study, both classes had an average percentage of indicators on critical thinking in the high category. The average percentage score of critical thinking skills in class X IPA 2 of SMA Negeri 13 Semarang is 62.9% with a grade completeness reaching 80.6% and the average percentage score of class X IPA MA Nurussalam is 78.3% with a grade completeness reaching 100 %. The highest indicator of critical thinking ability that can be achieved in class X IPA 2 of SMA Negeri 13 Semarang is to determine the actions taken . The students of Class X Science 2 of SMA Negeri 13 Semarang are familiar with the problem based learning model, so it is natural to indicators determining the actions taken at a high level . The lowest critical thinking indicator is analyzing the argument . The indicator is low because students are not familiar with the learning model that gives rise to an analysis of an argument so that the PjBL learning model is the right solution to increase the students' analysis of argument power . In class X IPA MA Nurussalam, the highest critical thinking ability indicator that can be achieved is defining a term and considering a definition . The ability to define terms and consider definitions can be honed with a lot of reading. The ability of class X IPA MA Nurussalam students in defining terms and considering is high definition can be based because they read a lot of books or learning resources. The lowest critical thinking indicator is to consider whether the source of information can be trusted or not. Although the ability of class X IPA MA Nurussalam students in defining terms and considering a definition is high because they read a lot, but they have not been able to distinguish and consider whether the source of the information they read is reliable or not. That matter lacking because students do not yet know the sources/sites that are trusted among the world of education.

In the second test at the last meeting of this research, both classes of research had an average percentage of critical thinking indicators in the high category. The average percentage of critical thinking ability scores in class X IPA 2 of SMA Negeri 13 Semarang is 75.1% with a class completeness reaching 77.8% and the average percentage of critical thinking ability scores in class X IPA MA Nurussalam is 80.0% with class completeness reaches 100%. The highest indicator of critical thinking ability that can be achieved in class X IPA 2 of SMA Negeri 13 Semarang is to determine the outcome of consideration . This indicator has experienced a lot of improvements due to the application of the PjBL learning model that hones the ability to understand student readings so that they can consider the results read from the reading source well. The lowest critical thinking indicator is analyzing the argument and considering whether the source of information is reliable or not . Although these two indicators are the lowest, there have been improvements when compared to the first test. In class X IPA MA Nurussalam, the highest critical thinking ability indicator that can be achieved is determining the outcome of consideration . This indicator has experienced a lot of increase due to the application of the PjBL learning model that spurs students to more actively explore information. The lowest critical thinking indicator is determining the action taken. On this indicator, the ability to take action decreases because students focus on the project being made, so it is not optimal in preparing for the second test. Both of these classes experienced an increase in the average percentage of critical thinking skills scores. Class X IPA 2 of SMA Negeri 13 Semarang experienced an increase of 12.2% and Class X of IPA MA Nurussalam experienced an increase of 1.7%.

Regarding the product results students from the two schools are not varied enough, because they are limited by the material used. On average they choose to make posters, even though the theme is different. The value of the product results can be seen in Table 7.

Table 7. Data on the results of senior high school students products

Group	Score			
	SMA Negeri 13 Semarang		MA Nurussalam	
	XIPA2	Desc	XIPA	Desc
Group 1	86.7	VH	80.0	VH
Group 2	73.3	H	53.3	M
Group 3	66.7	H	60.0	H
Group 4	83.3	VH		
Group 5	70.0	H		
Group 6	53.3	M		
Average Percentage	72.2	H	64.4	H

Description :
VH = Very High, H = High, M = Medium, L = Low and VL = Very Low

The best student product results are based on certain criteria. The criteria include; material planning stage, preparation of tools and materials, processing techniques, work safety, security and cleanliness, physical form of the product and innovation . At class X IPA 2 SMA Negeri 13 Semarang , group 1, which has the highest value with the value of 86.7, while the class X IPA MA Nurussalam , group 1 also has the value of the highest value 80.0. The product results can be seen in Figure 1 and Figure 2.

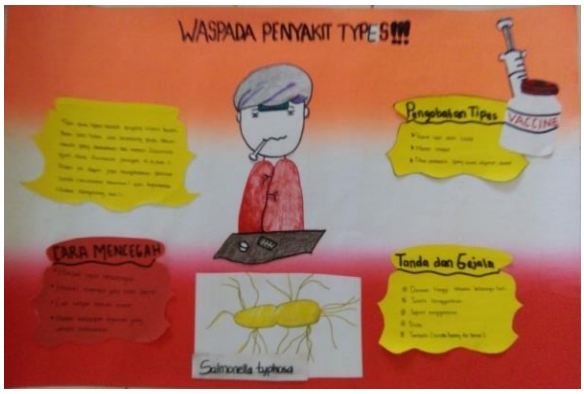

Figure 1. Product group 1 of SMA N 13

Figure 2. Product group 1 MA Nurussalam

Based on the results of a research analysis the effectiveness of the PjBL learning model on the collaborative ability and critical thinking of senior high school students in the two different schools can be discussed as follows.

First , the PjBL learning model is effective to students collaborative abilities. This can be seen in the average percentage of the collaborative level in the high category. In class X IPA 2 of SMA Negeri 13 Semarang, the maximum collaborative indicator is being able to respect individual differences. With the attitude of being able to respect individual differences, each group in class X IPA 2 of SMA Negeri 13 Semarang can discuss well in teaching and learning activities. This is similar to the statement of Putri et al. (2018) that collaborative abilities can train students to contribute individually and to practice an attitude of responsibility and respect with the diversity of other group members. In class X IPA MA Nurussalam Semarang, the most optimal collaborative indicator is to be flexible with the opinions of all members. Having a flexible nature of the opinions of all members will smooth the course of the discussion and avoid discussion from time-consuming debates, because there be an intellectual conflict in the discussion. This is similar to the statement of Saifulloh et al. (2015) that being flexible to the opinions of all members is very useful for avoiding discussion to endless intellectual conflicts and bringing a conclusion to the discussion. Collaborative indicators that still need to be maximized from the two schools are to help one another in the group . In each group, each student has received their respective assignments. Each student has the ability to complete the task obtained from the group. There are students who without the help of their friends

can complete their assignments and some are not. In the discussion it was seen that the group task completion was not yet compact so that the time given was not enough. According to Layli (2012) that in a discussion or collaborative learning a good and compact collaboration is needed so that the problems encountered in the discussion are quickly resolved.

Second, the learning model PjBL effective against the students' critical thinking skills. This can be seen in the increase in the average percentage of students critical thinking levels on both test results. Indikator success in the learning process can be measured on the quality evaluation tools. Measuring instruments in the form of essay questions that have been tested and have been tested for validity (Poernomo et al., 2018) . In class X IPA 2 of SMA Negeri 13 Semarang, the most maximum of critical thinking is determining the actions taken, with an increase of 0.33%. An increase in the indicator of courage to determine the action taken, than the level of critical thinking skills of students in class X Science 2 of SMA Negeri 13 Semarang can be measured. According to Handayani et al. (2016) critical thinking skills can be known from the increase in test results between the initial test and the final test. In line with that statement, Hidayah et al. (2019) revealed that the ability to think critically can be known from the differences in the results of the pretest- posttest. In class X IPA MA Nurussalam Semarang, the most critical indicator of critical thinking is defining the term and considering a definition with a 0.08% increase in the average level of critical thinking skills. An increase in the indicator defines the terms and consider this definition, then the level of critical thinking skills of students in class X MA Nurussalam Semarang can be known. Apart from understanding a definition, students will also easily understand what is learned. According to Agusman's statement (2016) that critical thinking is a high-level thinking ability that includes the process of analysis, synthesis and evaluation and to reach at these three stages must first understand the definition.

The PjBL learning model is an innovative learning model that is student-centered and places the teacher as a motivator and facilitator. According to Lestari et al. (2016) students are given the opportunity to work independently to construct their learning. Students also work on assignments, solving problems with their groups so that communication is established between friends (Kristanti et al., 2016) . In addition, according to Yuniartiek et al. (2015) PjBL learning aims to produce products or projects tangible. Such a learning model system certainly makes students' creativity and abilities increasingly honed (Titu, 2015) . Among the students honed abilities are collaborative skills and critical thinking of students.

CONCLUSION

Based on the objectives, analysis of research data and discussion, then in general it can be concluded that:

a. The PjBL learning model is effective on collaborative abilities and enhancing students critical thinking skills at SMA Negeri 13 Semarang on the material of structure, way of life and the role of bacteria in life.
b. The PjBL learning model is effective on collaborative abilities and enhancing students critical thinking skills at MA Nurussalam Semarang on the material of structure, way of life and the role of bacteria in life.

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