

The effectiveness of problem-based learning model to increase the students' critical thinking skills

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ABSTRACT

The previous research result showed that the learning model based on the investigation could increase the students' critical thinking skills. The aim of this research was to measure the effectiveness of the using of problem-based learning model to increase the students' critical thinking skills. The research design was quasi-experiment by using post-test only design. The population of this research was the eleventh grade students of science which contained 124 students of SMAN 6 and SMAN 7 Kupang that were chosen randomly. The treatment that was given in this research was problem-based learning model for the experiment class and conventional model for the control class whereas the given materials were the reaction rate. The instrument that was used in this research previously validated by two experts of theory and material. The result of this research showed that the students who studied in experiment class had different critical thinking skills better than the students who studied using conventional model.

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1. INTRODUCTION

The most important role of education is preparing the graduate to be able to compete and deal with every challenge in 21st developing era [1, 2]. The condition of Indonesia education, nowadays, is doing some changes in education area to solve various challenge in developing of the recent modern era. There are some changes that are done such as changing the curriculum from School-based Curriculum or KTSP to 2013 Curriculum (K13). The purpose of implementing K13 is preparing people in Indonesia to live as an independent person that has some characteristics such as religious, productive, creative, innovative and affective thus they can contribute in the society, nation, country and world civilization [3].

To achieve the education objective above, all competences in learning process that are had by the students must be optimized and developed by implementing learner-centered [1, 4]. This matter is based on one of the modern education objectives that is building the individual that know what and why they learn thus they must be able to build their own knowledge [5]. Therefore, as young generation, the students must be given and completed themselves by critical thinking skills [6] and problem-solving skills because both skills are the basic skill in working space [1, 5, 7, 8].

The critical thinking skill is competent activity that achieves various intellectual standards such as clearness, relevance, coherence, and evaluation toward the observation and other information sources [9]. According to [10] the critical thinking skill is reflective thinking to decide something that must be believed and done. Besides, this skill is the skill that is included in high order thinking skills [11] that contains cognitive analysis development level, evaluation and creating [12, 13]. Moreover, this skill is the high thinking skill where the thinking process is deep and logical, so it does not accept holistically all of new

information that is gotten except through reflective thinking then produces a decision to be believed and applied in daily life.

The critical thinking skill needs to be grown in the students' character and implemented in teaching and learning process [14] especially in chemistry lesson since this skill is very important and focused on education. So that, it can help the students to develop their academic achievement [15, 16] and produces the competent and skilled students in solving problem in their daily life [8]. Moreover, this skill is the important skill for the success life in the dynamic and complex world [11]. The connection between this skill and chemistry science especially reaction rate materials is helping the students to develop their critical thinking skills [14] because basically the essences of science especially chemistry are empirical, tentative, inferential, creative and theoretical. Besides, it is planted in the wide culture and built without any certain scientific method [17]. So that, the chemistry is a subject that is relatively important in science education [18].

Based on some researches that are done in many fields such as social knowledge, it is found that the students who have graduated from many countries do not have ability to compete in global scale because they do not have critical thinking skills. This matter is also supported by the research done by Chartrand [19] where it shows that there are 70% graduated students of high school who do not have critical thinking skill. Education in Indonesia is also still far away from other countries especially relating to national examination in which up till now this test still uses low thinking level that focuses on saving information of knowledge [20, 21]. The implementation of critical thinking skill and solving problem can increase motivation and students' learning achievement including chemistry lesson, because of gathering some thinking skills the students can be able to increase the effectiveness and to maintain their learning achievement well [1].

Developing the critical thinking skill and solving problem can be learnt with many activities, observation programs, and solving many problems [1, 8, 22] especially in chemistry materials of reaction rate. The chemistry materials tightly relates to the human life and needs observation to solve the problem inside. Therefore, to support the development of critical thinking skills the students need to implement the appropriate learning model [11]. The implementation of learning model in teaching and learning process can influence the learning and can decide the final result of the students' critical thinking skill [8, 14, 23]. The learning model that can increase the critical thinking skills and increase the students' independent learning skills especially for chemistry lesson is problem-based learning model [24, 25] where the implementation uses complex problem in real world [26] to motivate the students in identifying and analyzing the needed principle and concept to arrange the solution to solve the problem in chemistry [27]. There are three important points in problem-based learning model that are problem, tutor and learner [28, 29]. The given problem is not structured, so it needs the various solution to solve it. Besides, it can indirectly develop the students' cognitive ability [30, 31]. Moreover, the students are also collaborated with other groups to look for the solution in solving problem [24, 32] whereas the teacher has a role as mentor or facilitator in teaching and learning process to give metacognitive problem, to prepare the learning environment that focuses on the students and to give the instruction without directly gives the students a solution of the given problem [29, 31, 33, 34].

Various researches that are already done stated that the implementation of problem-based learning model can increase the learning achievement [35], the students' motivation [36], positive response toward chemistry [25, 35], and the success if it can be implemented in learning process and accepted in various disciplines [30].

Based on the explanation above, it needs to implement the problem-based learning (PBL) model to support the development of the students' critical thinking skill relating to the chemistry materials of reaction rate. It is also caused by the chemistry level that explain many problems relating to the students' real world then PBL model can help the students to increase the skills to solve the problem [28], to analyze, to evaluate, and to conclude various solving problems that become the aspects in critical thinking [26, 37]. The problem-based learning model also requires the students to be able to collaborate with groups in solving and arranging the problem [34]. Looking forward the effectiveness of problem-based learning model to increase various skills, this research aimed to elaborate the effectiveness of problem-based learning model to increase the critical thinking skills in chemistry knowledge about reaction rate materials.

2. RESEARCH METHOD

2.1. Research design

This research is quasi-experiment research by using post-test only design [38] that is aimed to measure the influence of PBL model relating to the students' critical thinking skill of reaction rate materials through empiric study and theoretic review. This research has dependent and independent variable [39]. PBL model and conventional model are independent variable whereas the critical thinking skill is dependent variable.

2.2. Population and sample

The population of the research is the eleventh grade students of science major, and the sample of this research is 124 students that are chosen randomly [38]. The sample focuses at SMAN 6 Kupang and SMAN 7 Kupang that is in B status of accreditation, and both of them are implemented curriculum 2013 and rarely use chemistry laboratory. This research uses two classes that are experiment class (60 students) and control class (64 students). Both classes get the different treatment where the experiment class is given the PBL model treatment whereas the control class get the conventional learning model. The chemistry lesson has four hours a week and all students follow the teaching and learning process about reaction rate materials.

2.3. Data collection

Collecting the data of critical thinking skill is done once by doing post-test. It is done after the students are given the treatment during learning process. This given treatment is PBL model in experiment class and conventional model in control class. The learning process is done by following every syntax that is contained in PBL model [34] and chemistry class about reaction rate that is given for six meetings.

2.4. Research instrument

The instrument used in this research is critical thinking skill test that contains of seven essays. The used instrument is developed by the researchers and already validated by the chemistry expert and theory expert from Yogyakarta State University, Indonesia. This instrument is developed by considering the indicators of critical thinking skill that are basic clarification, decision making, conclusion, and continuation clarification [10]. The used instrument is previously done validation test and reliability test with skor 0.76 and 0.87.

2.5. Data analysis

The result of the students' critical thinking test toward the chemistry knowledge that is already gotten then analyzed by using t-test independent sample by using application of SPSS 23 windows version [39] to measure the difference of PBL model and conventional model to increase the students' critical thinking skill. Nevertheless, before the independent t-test sample is done, the data must be tested by precondition test that are normality and homogeneity data test. The results of these tests show that the research data for experiment and control class are distributed normally and homogeneous it can be seen in Table 1 and Table 2, so it can be done the independent t-test of sample.

3. RESULTS AND ANALYSIS

The 95% of interval reliance is used in this research to identify alpha or significance level of 0.05 that is used in whole analysis. The precondition tests that are done or must be fulfilled before doing t-test of independent sample are normality test and homogeneity test. If the significant value is smaller than 0.05, it will cause the rejection of hypothesis because both groups of research –experiment and control class- come from abnormal population and inhomogeneous [39].

Table 1. Normality test of critical thinking skill

Class	Kolmogorov-Smirnov ^a		
	Statistic	df	Sig.
CTS experiment	0.096	60	0.200
CTS control	0.095	64	0.078

The normality of post-test score for every group is evaluated by using Kolmogorov-Smirnov test. Table 1 shows that the post-test score of experiment class and control class in Kolmogorov-Smirnov test has significant score bigger than significant score of 0.05 in which experiment class is 0.200 and control class is 0.078. So that, the data result from the post-test of critical thinking skill for both groups comes from normal population.

Table 2. Homogeneity test of critical thinking skill

Levene statistic	df1	df2	Sig.
0.062	1	124	0.772

The homogeneity of post-test score for every group is evaluated by using Levene Statistic test. Table 2 shows that the post-test score of critical thinking skill in the experiment class and control class has significant score bigger than significant score of 0.05, so the data result from the *post-test* of critical thinking skill is homogeneous. Based on both precondition tests above, the results give a conclusion that the data is distributed normally and homogeneous, so the t-test for independent sample can be done.

The t-test toward independent sample aimed to find out the differences in the unconnected samples. The result of this test can be interpreted as if the significant value (2-tailed) is bigger than 0.05, there is no difference intergroup and vice versa.

Table 3. T-test toward independent sample of critical thinking skill

	t-test for Equality of Means			
	t	df	Sig. (2-tailed)	Mean difference
Equal variances assumed	2.351	124	0.020	5.705
Equal variances not assumed	2.349	122.590	0.020	5.705

In Table 3, the result of t-test toward independent sample of critical thinking skill between experiment class that is given PBL model and control class that is given conventional model shows that there is a difference of critical thinking skill in both classes since the significance value (2-tailed) is less than 0.05.

3.1. Post-test score of critical thinking skill

The result test of critical thinking skill shows that the students in control class have the lowest average with the post-test value of critical thinking skill ($M = 31.84$, $SD = 13.09$) whereas the result of the experiment class shows better value ($M = 37.55$, $SD = 14.13$). It means that there is a difference in both research groups ($t = 2.349$, $p = 0.02$). Cohens'd value ($d = 0.42$) shows that the experiment class that is given PBL model has significant influence toward the students' critical thinking skill.

The research results show that the students that use problem-based learning model through theoretic and empiric studies have better critical thinking skill than the students that are taught by using conventional model. This result is consistent with [40] statement, [41] where their separated studies show that the students who learn by using PBL model have better critical thinking skill than the students who use conventional model. The next research result explains that PBL model is more effective to increase the understanding and implementing the concepts [42] than others and learning by using PBL model can motivate and increase the learning achievement, independent research, and critical thinking skill [13, 43-45]. The effectiveness of PBL model takes place on giving problem and collaborating between the students and the teacher as a tutor in learning process [27, 46]. The research that is done by Overton T. L., and Randles C. A., [23] shows that the implementation of PBL model in chemistry knowledge always increase since the students become the center in teaching and learning process. Besides, it has dynamic characteristic, and the students individually plan the solving problem scenario where it can increase their ability to communicate each other, to work in groups, and to solve the chemistry problems [13]. Moreover, the implementation of PBL model can reveal the students' academic skill [46].

The application of problem-based learning models in the experimental class proved effective in helping students solve problems related to the material reaction rate. This is evidenced by the ability to design experiments and prove the hypotheses they have made at the beginning of the meeting. Students can give answers related to problems in life that are related to the material reaction rate, such as vegetables stored in the refrigerator last longer than vegetables that are not stored in the refrigerator. Factors that influence the process are temperature factors, the concept is that the higher the temperature, the faster the rate of vegetable decay, so that when the vegetables are stored in the refrigerator the rate of vegetable decay is longer because the temperature of the vegetable is low. The learning process that relates directly to students' lives is proven to be effective in helping students' long-term memory and increase students' motivation to learn individually or in groups.

The different average of critical thinking skill between experiment class and control class is caused by the different treatment of learning model. PBL model is based on the conclusion that the complex problem situation will increase the students' curiosity, so they involve in the investigation [27, 47]. In doing the investigation, the research framework is also arranged by the students, so the learning activity is centered on the students [48]. The learning activities that are done during the research also show that the students in experiment class can memorize better than the students in control class about the reaction rate materials. It can be happened since they interact directly with formulating the problem and solution to solve the

problem relating to the reaction rate materials. The investigation process also shows that the students can divide the tasks in solving the problem and being responsible to solve it.

Therefore, the teacher's role as facilitator must be run optimally to arrange and guide the students to be able to develop every skill that is not showed up yet, such as critical thinking skill [49]. The critical thinking skill is very important to be mastered by people today to gather much information that is developed in the world. It becomes the important point why people must have critical thinking skill to understand and get the meaning of these information [50]. The worst decision making and problem solving, the resource abuse, and the absence of a sustainable policy direction are the bad consequence that must be gotten if there is no implementation of critical thinking skill in teaching and learning process [49]. Therefore, supported by the implementation of PBL to reveal many solutions to solve the problem in the real world makes the critical learners are not afraid to face the world challenge that is dynamic and complex [45]. The problem-based learning model actually can help the students to be able to cooperate with the others to find out the solution. The ability to be able to cooperate with the others is also needed in working field now, so the importance of PBL model more reveals the students' cognitive skill and collaborative skill. Thus, it should be done when PBL model must be implemented as learning model in teaching and learning process.

4. CONCLUSION

Problem-based learning (PBL) model through empiric and theoretic review shows positive result to increase the critical thinking skill rather than the implementation of conventional model. Based on the research result, the researchers recommend for all teachers to implement PBL model in lesson plan and teaching and learning activity to increase the students' academic skills. PBL model can also help the students to save the gotten information since they interact directly with the problems, so it becomes the deep part of their long-term memory. The next research is hoped to be able to reveal other high order thinking skills that are needed in this modern world and to answer every challenge in changing world that is more dynamic and complex.

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