Developing Critical Thinking of Middle School Students using Problem Based Learning 4 Core Areas (PBL4C) Model

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Abstract. Traditional methods such as rote learning and memorization in teaching science create passive students in science classrooms. The impact of this continuous action for many decades is inactive learners who cannot develop higher order thinking skills. Based on the performance test, students' critical thinking skill in Public Middle School 3 Pontianak was in low level although their achievement score were higher than school standards. The purpose of this study is to develop critical thinking skills of middle school students using Problem Based Learning 4 Core Areas (PBL4C). The design of this research is classroom action research with two cycles. Data has been collected using observation checklist, rating scale, self and peer assessment. Research findings reveal that students experience development from 11.11% to 88.45% in identifying the problem correctly, 37.03% to 76.92% for sub skills distinguish knowledge and opinion, 18.51% to 65.38% for sub skills providing possible solution, 22.22% to 69.23% for sub skills making decision, and 11.11% to 69.23% for sub skills identifying the impact of the implementation of their solution. In conclusion, the findings indicate that development of students' critical thinking skills occurs when PBL4C model applied in science classroom. These findings suggest that teachers should act as facilitator in a classroom as well as should provide meaningful learning resources that can benefit students' critical thinking skills. On the other hand, students should practice constantly to offer a sharp, accurate and appropriate solution.

1. Introduction

Nowadays, the development of teaching approaches in physics education has been changed. Transforming from the rote learning, memorization and other traditional methods in teaching, currently students are expected to be more involved in the teaching and learning processes as well as graduate improved and ready to be successful in today's global economy. In order to achieve this idea, students must learn the essential skills, for instance problem solving and collaboration skills within their context of core course knowledge such as physics. This concern becomes the main focus in the framework for 21st century learning. This framework develops some skills such as learning and innovation skills, information, media, and technology skills, and life and career skills that must be mastered by students to be successful in work and life.

I have been teaching physics for nine years in a regular public school. The last four years of my teaching experience was in top school in West Kalimantan Province. Based on my experiences, I have found that during my teaching practice, most of my students are not able to express clear ideas and transfer their knowledge to solve real-world problems in physics class. For example, students understood about metal and non-metal classification, but they failed to identify the correct material

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from the available resources that they needed to design a safe electrical circuit. Another example, students mastered the methods of separating mixtures such as distillation, filtration, and chromatography, but they were unable to identify which was the best material to purify water. Students were unable to develop their critical thinking in solving problems and judged a decision using scientific reasons. Based on the performance test of those experiments, the critical thinking achievement of each aspect of students from Grade VII D Public Junior High School 3 Pontianak Year 2013 is provided into the table below.

Table 1. Critical thinking achievement of students from grade VII D Public Junior High School 3 Pontianak Year 2013.

No.	Aspect of critical thinking	Percentage of student's performance
1.	Identifying problem correctly	11.11 %
2.	Distinguish knowledge and opinion	37.03 %
3.	Providing possible solution	18.51 %
4.	Making decision	22.22 %
5.	Identify the impact of the implementation of their solution.	11.11 %

Based on the Indonesian school based curriculum (2006), the central education authority developed general competences and minimum content outlines while individual teachers developed their subject curricula, including formulating learning objectives, selecting content, teaching strategies as well as developing learning evaluations independently. This curriculum stressed the achievement of standardized competences that students had to achieve, and the development of life skills to prepare graduates to survive in life [1]. In order to develop an evaluation, teachers must determine the minimum standard score, which involves complexity of content knowledge, availability of learning resources, as well as students' intake. The calculation of minimal standard score is started from determining the minimal standard score of indicator, basic competency, and standard competency respectively. The final calculation will result in the minimum standard score of a course, in this case, science for grade VII. In Year 2012/2013, based on the calculation, the minimum standard score for students in science was 80 out of 100. For this reason, all students who achieved a score average of 80 out of 100 for each aspect of critical thinking were assumed to have adequately developed their critical thinking skills.

According to my observations and the result of the performance test, students' critical thinking currently was very low. This condition could be the impact of implementing traditional methods in teaching physics such as rote learning and memorization. Those methods were not providing enough space for students to develop their multi dimensional skill, mental processes as well as universal harmonious values. Students were not used to working cooperatively, appreciating their diversity, and effectively analyzing. In addition, they also were not fostered to evaluate evidence, arguments, and alternative points of view before judging a decision and solving various types of problems with both conventional and innovative methods. In other words, students were not able to transfer their knowledge to solve problems in real life scientifically. Therefore, teaching and learning activities at this point were not preparing students to adapt and survive as well as to succeed in work and life.

During my participation in the Customized Course for Indonesian Secondary Science and Mathematics Educators at RECSAM, Penang, Malaysia on September 2012, I encountered the new invention in teaching approach. I was very impressed with its features. The instructors integrated the content of the lesson and some events that usually happen in our daily life in promoting an instructional strategy or learning model. This model was developed and focused on four core areas of physics education. Those areas were multi dimensional skills, multi disciplinary content knowledge, thinking skills and universal harmonious values so that students were prepared to be able to solve their problems in daily life. Thus both knowledge and learning activities became a meaningful learning for students. Therefore, in order to help teachers to combine the content knowledge and real life problems in teaching physics, teachers could apply the PBL4C Model as one of the alternatives.

When I reviewed some literatures, there were ample evidences showing that the enactment of PBL4C model in physics classroom was able to develop students' critical thinking skills. For example, Larmer and Mergendoller documented that the use of PBL4C model in secondary school was more meaningful if students were asked to conduct real inquiry [2]. They further suggested that PBL4C model by inquiry had developed students' high order thinking skills such as critical thinking. The most fascinating aspect of PBL4C

Model is the context problem in lesson based on the real life problem. Numerous studies corroborated that PBL was an effective approach to cultivate critical thinking and problem solving skills [3],[4],[5]. This model is students' centered; developing students' accountability, responsibility and lifelong skills. It also promotes problem-solving skills, asks student to apply content realistically, and stimulates creative and critical thinking. Considering the benefits of this model, I would like to conduct classroom action research focusing on the implementation of PBL4C Model and investigate its impacts in the development of students' critical thinking skills. Therefore, this Classroom Action Research questions are as follow: How to develop students' critical thinking skills using Problem based Learning 4 Core Areas (PBL4C) Model? What are the problems that students have in developing their critical thinking skills?

2. Research question and purpose of this study

The purpose of the study is to investigate the development of critical thinking skills of middle school students using Problem Based Learning 4 Core Areas (PBL4C). This teaching method is based on the active learning and constructivism learning theory and inquiry based science education. The central focus of constructivism is the student as a self-governed creator of knowledge [6]. Constructivist teaching should actively engage students in relevant and interesting problems; provide opportunities for students to discuss problems with each other and the teacher; give students time to reflect and test their ideas; and encourage students to reflect on other students' ideas [7]. In addition, Savery and Duffy considered Problem Based Learning (PBL) as one of the best examples of constructivist-learning environment [8].

3. Methodology

Research design of this study is class action research with two cycles. The main purpose of this study is developing critical thinking of middle students using PBL4C model. This study is relevant to the central idea of action research which is to intervene in a deliberate way in the problematic situation in order to bring about changes, and even better, improvements in practice [9]. This study has been conducted in Public Junior High School 3 Pontianak (SMPN 3 Pontianak), West Borneo, Indonesia. SMPN 3 Pontianak is an academically strong middle school in West Borneo located in Pontianak which means this school only accepts students based on the high level of students' academic performance in elementary school. Based on results of the national examination Year 2013, five students from SMPN 3 Pontianak become top ten students who achieved the highest score in that province, thus this school is considered as the best middle school in West Borneo Province this year similar to the previous years. This study had been conducted specifically in a physics course for grade VIII Term I Year 2014/2015 and the topic was Force and Motion. The course meeting is twice a week, 120 and 80 minutes, from July to December every year. This class action research was conducted for 6 weeks with the topic force and motion. The study started on the third week of July 2014 and continued to the fourth week of September 2014. Students from grade VIII were the participants of this study. The number of students was 32 and consists of both female students and male students. Students from grade VIII usually have common age, economic, social, and intellectual ability background thus will reduce or minimize the impact of these backgrounds on their critical thinking skills.

3.1. Procedures

Research for this study consists of four main phases: (1) planning, (2) implementation, (3) observation, and (4) reflection.

3.1.1. Planning. In this section, the steps to be implemented in this action research are planned. The researcher reviews the standard competency and basic competency in Curriculum 2013. After reviewing those competencies, especially for the topics of force and motion, the researcher determines the study objectives, learning experience, indicator of achievement, and teaching methodology, in this case, PBL4C. The next step, the researcher will design the lesson plans comprised of learning objectives, two scenarios, learning resources, and instruments of assessment.

Integrating PBL4C in lesson plans in the science classroom is based on the main principle of PBL which is that "all lesson begins with a contextual problem" where it provides a new dimension, direction and motivation for learning [10]. Thus, the learning activities will start with a contextual problem as the first stage. The contextual problem is delivered to all groups in the classroom. This contextual problem provides the opportunities to examine and try out what they know and what they need to know, discover what did they learn, develop skills for achieving higher performance in teams, and improve the communication skills [10]. Students are given a worksheet and they have to fill in the blank columns to identify the problem and the fact list. In addition students need to list what they need to know to make inferences, and what they need to know to identify implicit assumptions and possible solutions based on the contextual problem.

The second stage is that students are given two scenarios. A scenario is a unique component of PBL that is especially suited to introduce challenge and thereby provide good opportunities to solve the problem. Appropriate management of change is by no means an inborn skill but one that needs knowledge, observation, communication, accommodation, personal practice and evaluations. In scenario 1, each group test their decision or model on how to solve the problem through experiment. They determine the strength and weaknesses of the decision or model of the problem and whether it works or not in solving the problem. In scenario 2, they present their plan or model, its strength and weaknesses on solving problem, and/or recommendation to solve the problem to their group as well as their classmates. This presentation covers the identified problem, questions, data collection, data analyses, possible solutions and recommendations based on the data analyses. In their plan, they not only learn the content knowledge, thinking processes, but also practice the skills and values in decision making to figure out the possible solution and used higher-order thinking skills [11].

Through these processes, students discuss, analyze, and argue, as well as provide possible solutions in order to obtain the mutual understanding about the contextual problem. Those processes develop students' ability to identify the problem correctly, analyze arguments, ask clarifying questions, judge the credibility of a source or observation report, make inferences, identify implicit assumptions, and decide strategies and tactics to solve the problem. Through these activities, students are able to improve their critical thinking on those sub skills.

3.1.2. Implementation. The lesson plan had been implemented in the classroom. The researcher promoted the problem about force in real life through a video. After all students understand about the main problem revealed through the video, the researcher promoted scenario 1 which was a real life problem. Students formed a group consisting of 4 members and discussed the possible solutions for the problem. Then, students designed their model using appropriate materials and then tested whether it works or not in solving the problem.

After students completed their tasks in scenario 1, the researcher continued to the scenario 2. In scenario 2, each group presented their solution in front of the class. They will showed their model to other students and explain if the model works properly in solving the problem or not, its strength as well as its limitation. Students also informed the group about suggestions what they will do in the future in designing the better model based on their experience in testing it. At this stage, the researcher provided self and peer assessment to obtain information about the developing students' critical thinking. Those instruments will be filled and collected after the class is completed.

3.1.3. Observing. While students designed, tested, and promoted their model, the researcher observed the specific elements of critical thinking that had been developed through an observation checklist.

The specific elements consist of four categories: (1) Elementary clarification, (2) Basic support of an argument, (3) Inferences, (4) Advanced clarification, (5) Strategies and tactics [12]. This observation started from the beginning of scenario 1 through the end of scenario 2.

3.1.4. Reflection. Based on the result of self-assessment, peer assessment, as well as observation, the researcher defined the number of students who develop their critical thinking for each sub skills. The development of critical thinking skills are determined by observing carefully the number of critical thinking sub-skills used in solving problem. These sub-skills are stated in the self-assessment form, peer assessment form, and rating scale. Based on those findings, the researcher conducted interviews with students in order to obtain the clear picture of the development of students' critical thinking in applying PBL4C model as well as reduced biases and minimize different interpretation between the researcher and students. The researcher also defined some common problems in applying PBL4C in the classroom and reduced it on the next second cycle.

3.2. Data collection

Related to the Research Questions, some instruments were developed to document any data needed in this research. The types of instrument are summarized in the following table:

Table 2. Research questions, data to be collected, and instrument that will be used to collect the data.

Research Question	Data to be collected	Instrument
How to develop students' critical thinking skills using Problem based Learning 4 Core Areas (PBL4C) Model?	Data that indicated students' attitude towards critical thinking skills: 1. Identifying problem of the experiment correctly; 2. Distinguish knowledge and opinion; 3. Providing possible solution; 4. Making decision; 5. Identifying the impact of the implementation of their solution.	Self assessment Peer assessment Rating scale Checklist
What are the problems that students have in developing their critical thinking skills?	Data that indicated students' difficulties in developing critical thinking skills. 1. Identifying problem of the experiment correctly; 2. Distinguish knowledge and opinion; 3. Providing possible solution; 4. Making decision; 5. Identifying the impact of the implementation of their solution.	Self assessment Peer assessment Rating scale Checklist

Data collected during this research study included self-assessment and peer assessment, observation checklist and rating scale. Self and peer assessment instruments had been filled by the students after they complete the scenario 2 at the end of meeting. The researcher observed the development of students' critical thinking through observation checklist and rating scale. The observation had been conducted at the beginning of scenario 1 through the end of scenario 2.

As a qualitative research study, data has been analysis qualitatively. Description based on the rich data yielded from triangulation using various instruments for such a data may provide a clear picture of the findings. The function of triangulation is to locate and reveal the understanding of the object under investigation from "different aspects of empirical reality" [13]. The common trends arising from the data will be segmented and labeled accordingly to build meaning and interpretations before reporting the findings and conclusions of this study.

4. Results and conclusion

SMPN 3 Pontianak is an academically strong junior high school in West Kalimantan located in Pontianak City which means this school only accepts students based on the level of students' academic performance in elementary school. Based on the results of the national examination Year 2013, five students from SMPN 3 Pontianak become top ten students who achieved the highest score in that province, thus this school is considered as the best junior high school in West Kalimantan Province this year similar to the previous years.

4.1. Description of the first cycle

Target observation of this research is students' activities in learning process in cognitive and affective aspects related to Newton's third law. Results from self-assessment and observation as well as learning objectives are appropriate with the research instruments in planning, main activities and closure. Results of the students' critical thinking skills achievement sub skill: Identifying problem of the experiment correctly. Data from peer assessment perform 57.69% students are able to identify the problem correctly. This finding is supported by the data from observation (checklist) that indicate 50% students are able to identify correctly. Therefore, there is an increasing critical thinking skills compare to the data from initial research. The achievement increases from 11.11% (initial research) to 50%. Data from observation also indicate the 73.07% students have sensitivity to the feelings, level knowledge of others in various level yet only 15.38% students look for explanation and reasons and uses and cites credible sources.

Results of the achievement of students' critical thinking skills sub skill: Distinguish knowledge and opinion. Data from peer assessment indicate that students perform better in providing facts from the problem compare to mentioning opinion about the problem. There are 38.46% students always able to provide facts from problem and 23.07% students always mention the problem when groups share their results. Data from observation (checklist) also indicate that 38.46% students look for explanation and reason when they distinguish knowledge and opinion. Therefore, there is a development of critical thinking skills compare to the data from initial research. There is a slightly increase of achievement from 37.03% (initial research) to 38.46%. Data from observation also indicate the all student use and cite credible sources yet there is only 30.76% students who are able to be open minded and keep to the main relevant point.

Results of the achievement of students' critical thinking skills sub skill: Provided possible solution. Data from peer assessment indicate that students perform better in what they need to solve the problem rather than mention possible solution to solve the problem. All students always able to mention what they need to solve the problem and 30.76% students always mention possible solution to solve the problem when groups share their results. Therefore, there is an increasing of critical thinking skills compare to the data from initial research. There is an enhancement of students' ability to provide possible solution from 18.51% (initial research) to 30.76%. Data from observation also indicate 73.07% students are sensitive to the feelings, level knowledge of others yet there is only 30.76% students who are able to look for alternative when they provide possible solution.

Results of the achievement of students' critical thinking skills sub skill: Making decision. Data from peer assessment indicate that students perform better in making a decision towards the problem rather than providing logical reason in making a decision. About 50% students always able to make a decision towards the problem yet only 15.38% students sometimes provide logical reason when they make the decision. This finding is supported by the data from observation; 53.84% students look for alternatives when they make a decision. Therefore, there is an increasing of critical thinking skills compare to the data from initial research. There is an enhancement of students' ability to make a decision from 22.22% (initial research) to 50%. Data from observation (checklist) also indicate that all students take a position of an issue yet only 42.30% who change a position of an issue with good reason(s).

Results of the achievement of students' critical thinking skills sub skill: Identify the impact of the implementation of their solution. Data from peer assessment indicate that students perform better in

mentioning whether the solution work properly in solving problem and mentioning the weakness of their model compare to mentioning the strength of their model. There are 61.53% students always able to both mention whether the solution work properly in solving problem and mention the weakness and 19.23% students always mention the strength of their model when groups share their results. Therefore, there is a development of critical thinking skills compare to the data from initial research. There is a slightly increase of achievement from 11.11% (initial research) to 61.53%. Data from observation also indicate the all student take a position of an issue and sensitive to the feeling, level knowledge of others but only 57.69% students are open-minded.

Results from the first cycle reveal that there is a development of students' critical thinking skills for all aspects compare to the preliminary data. The largest development of students' critical thinking skills is in sub skill: Identifying the problem correctly. In these sub skills, students have significant development from 11.11% to 50%. Some other sub skills also have significant development for example making a decision towards a problem and identifying the impact of the implementation of their solution. However these developments are only occurred in basic level. In the sub skill: Making decision, about 50% students always able to make a decision towards the problem yet only 15.38% students sometimes provide logical reason when they make the decision. This data implies that students are able to make a decision of a problem but their proposed solution may not have scientific explanation or logical reason behind it.

Data from sub skill: Identifying the impact of the implementation of their solution also reveals a similar case. Students only master the basic level of critical thinking skills. 61.53% students always able to both mention whether the solution work properly in solving problem and mention the weakness yet only 19.23% students always mention the strength of their model when groups share their results. This finding implies that students are struggling to identify the strength of their model. They only focus in the final goal that is whether the solution works properly or not. They also give more attention to provide explanation and suggestion to overcome the weakness of their model rather than boost the strength of it. These findings disclose that students' critical thinking skills need to be improved to the advanced level in the next second cycle.

4.2. Description of the second cycle

Results from self-assessment and observation as well as learning objectives are appropriate with the research instruments in planning, main activities and closure. Results of the achievement of students' critical thinking skills sub skill: Identifying problem of the experiment correctly. Data from self-assessment perform 92.30% students are able to identify the problem correctly. This finding is supported by the data from observation (checklist) that indicate 88.45% students stated the main idea or thesis clearly, enthusiastically, and interestingly, for the audience. Therefore, there is an increasing critical thinking skills compare to the data from cycle 1. The achievement increases from 50% (initial research) to 88.45%.

Results of the achievement of students' critical thinking skills sub skill: Distinguish knowledge and opinion. Data from self-assessment indicate that 76.92 % students are excellent in recognizing the difference between knowledge and opinion. Data from observation (checklist) also indicate that 88.45% students give highly appropriate facts, excellent generalizations from facts, that support the thesis, sources of facts are credible, facts used well in making the argument. Therefore, there is a development of critical thinking skills compare to the data from cycle 1. There is an enhancement of achievement from 38.46% (cycle 1) to 76.92%.

Results of the achievement of students' critical thinking skills sub skill: Provided possible solution. Data from self-assessment indicate that 80.76% students are excellent in thinking of the possible solution toward the problem. Data from observation also indicate 65.38 % students actively look and encourage others to express points of view different from or opposing own. There is an enhancement of students' ability to provide possible solution from 30.76% (cycle 1) to 65.38%. However, data from checklist also reveal that 30.76% students mention all relevant and important alternative positions, present it fairly, and evaluate it properly. There are also 19.23% students attempting to rebut the

alternative position but they are ineffective or incomplete. These findings imply that although students perform excellent in providing solution, they still need to develop the abilities to evaluate and rebut those possible solutions fairly.

Results of the achievement of students' critical thinking skills sub skill: Making decision. Data from observation indicate that 69.23% students give excellent supporting reasons, good diversity, directly applicable. Therefore, there is an increasing of critical thinking skills compare to the data from cycle 1. There is an enhancement of students' ability to make a decision from 50% (cycle 1) to 69.23%.

Results of the achievement of students' critical thinking skills sub skill: Identify the impact of the implementation of their solution. Data from self-assessment indicate that 69.23%s students are excellent in providing new information. Furthermore, 69.23 % students are very clear in organizing and enhancing the argument and keep the audience interest focused on the main issues. Therefore, there is a development of critical thinking skills compare to the data from cycle 1. There is an enhancement of achievement from 61.53% (cycle 1) to 69.23%.

Results from the second cycle reveal that there is a development of students' critical thinking skills for all aspects compare to the data from cycle 1. The largest development of students' critical thinking skills is in sub skill: Identifying the problem correctly. In these sub skills, students have significant development from 50% to 88.45%. The development for sub skills distinguish knowledge and opinion is from 38.46% to 76.92%. The development for sub skills providing possible solution is from 30.76% to 65.38%.

Some other sub skills also have slightly development for example making a decision towards a problem and identifying the impact of the implementation of their solution. The development for sub skills making decision is from 50% to 69.23%. The development for sub skills identifying the impact of the implementation of their solution is from 61.53% to 69.23%. Data from checklist also reveal that 30.76% students mention all relevant and important alternative positions, present it fairly, and evaluate it properly, 15.38% students mention some of the relevant alternative positions, portray it properly, and evaluate it properly, and 53.84% students mention alternative positions but they are either not portrayed fairly, not evaluate it properly, or not relevant to the thesis. There also 19.23% students attempt to rebut the alternative position but they are ineffective or incomplete, 80.76% students do not attempt to rebut the alternative position. This data implies that students are struggling to evaluate and rebut alternative solutions properly.

5. Conclusion

Based on the analysis and the things that have been raised in advance, it can be concluded as follows:

- PBL4C model is a learning approach that can stimulate students' critical thinking
- The role of teachers in science learning process using PBL4C model is as a facilitator and learning resources that can guide and direct students to find solutions with respect to the provided problems.
- The courage and the ability to think critically is the basis for students in using PBL4C model to be more successful.
- The results showed that the use of PBL4C model develop students' critical thinking skills significantly. Students experience development from 11.11% to 88.45% in identifying the problem correctly, from 37.03% to 76.92% for sub skills distinguish knowledge and opinion, from 18.51% to 65.38% for sub skills providing possible solution is, from 22.22% to 69.23% for sub skills making decision, and from 11.11% to 69.23% for sub skills identifying the impact of the implementation of their solution.

This research study can further proposed some suggestions as follows:

- Teachers should be a facilitator and learning resources that can help students to study the learning material.
- Teachers conduct an analysis of the various issues involved, so it can be solved immediately.

- Students should be more active in implementing PBL4C model to increase their critical thinking skills.
- Students should be able to analyze a sharp, accurate and appropriate for any problems that occur to immediately be able to find a solution.

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