# Problem-based learning with argumentation as a hypothetical model to increase skills of critical thinking for students in SMP

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# Problem-based learning with argumentation as a hypothetical model to increase skills of critical thinking for students in SMP

## Abstract

**Abstract.** The Problem-Based Learning with Argumentation (PBLA) model is a development model of Problem Based Learning (PBL) added to the Toulmin Argumentation activity with the aim of increasing the critical thinking skills in SMP. The research aims to determine the feasibility of PBLA in terms of its validity and effectiveness. The research sample is two groups of students (class 1 and class 2), each class of 26 students. Before learning to use PBLA, each class was given a pretest and after learning to use PBLA were also given a posttest. PBLA validity data was obtained through validity sheets and analyzed through expert agreement. PBLA effectiveness data was obtained through skills of critical thinking tests and analyzed by paired t-test, n-gain, and two-average similarity test. The results of this study are the validity of the content and construct of the valid category with a score of 3.5 and 3.3. with a reliability of 77.10% and 77.67%. skills of critical thinking data showed a significant increase in skills of critical thinking at $\alpha = 5\%$, the average n-gain was categorized high, and there was a similarity in increasing skills of critical thinking for the two classes. In conclusion, PBLA is effective in increasing skills of critical thinking for student in SMP.

Key words: PBLA, skills of critical thinking, SMP.

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## INTRODUCTION

Skills of critical thinking are one of the most important skills for students to live in the 21st century where life phases enter the era of the digital revolution 4.0. Life of this era is characterized by including skills of critical thinking and solving of problem, skill of creative thinking and innovation, communication, and collaboration (Wagner, 2010). So, thinking skills are critical skills that all people require in all areas of human life (Abed et al, 20015) by problem-solving and decision-making (Carter et al, 2016). Bloom (1956) says that the most important analytical skills are analyzes (C4), synthesis and assessments/evaluation (C6). Analyzes involves the ability to evaluate and separates knowledge or systems in small pieces so that patterns or interactions are identified and the causes and consequences of a complex situation can be understood and separated. The synthesis is a way to describe and understand the data or knowledge needed to provide the appropriate solutions for the structure or pattern of an unforeseen scenario. Evaluation is the ability to analyze approaches, proposals, methodologies, etc. using appropriate parameters or established principles, to assess their performance or merit.

Seeing above definition, skills of critical thinking are very necessary for education at all levels (Wartono et al, 2017), of course in accordance with the level of thinking. This is important to prepare future generations who are able to answer the challenges of an increasingly complex and increasingly rapid era of development that is able to change the development of society is so rapid (Gumus et al, 2013). The Goverment of Indonesia Republic through Decree of Minister of Education of Culture of Indonsia Republic No 68 of 2013 concerning the structure of SMP curriculum states the need to change passive learning into critical. This is intended to get critical learning outcomes.

In fact, skills of critical thinking for students are still poor in the field. Research on skills of critical thinking conducted in two classes in SMPN 1 Galur produced n-gain of 0.26 and 0.19 in the range of values 0-1. In this case the teacher can actually teach skills of critical thinking (Choy & San Oo, 2012), but in reality most teachers lack the ability to teach skills of critical thinking effectively because of their low quality; most teachers still use traditional learning models such as speeches, questions, answers, and presentations. From the description above, the question arises, how to improve skills of critical thinking for students?

One model of learning in school today that have been believed to can to teach skills of critical thinking for students, namely by using model of Problem Based Learning (PBL), which has been developed by Arends (2012). The reality on the ground shows that PBL model constantly have weaknesses, especially students are still weak in giving argumentation (Semerci & Batdi, 2014). Sockalingam & Schmidt (2011) conducted a study with a sample of 34 using the PBL model, the results obtained showed the weaknesses of PBL, namely PBL would be effective if students had mastered the basic concepts to solve problems. When students do not have and do not understand the basic concepts, students have difficulty in problems solving because of arguments. The results of Celik et al (2011) found in a sample of 24 prospective teacher students using PBL to improve student learning outcomes in physics, but the ability to investigate and collaborative students to solve problems was still low. These two obstacles show that when students have adversity understanding basic consepts, students have difficulty arguing.

One of the most important learning goals is to increase skills of critical thinking. With one's skills of critical thinking one can solve complex problems. Skills of critical thinking must always be taught and practiced because they cannot appear by themselves following their physical development. Schools as formal institutions are obliged to teach and practice continuously skills of critical thinking to their students. Thus, this research is developing a new model that can train students with skills of critical thinking. By intervening in PBL with argumentation, there is a new model called Problem Based Learning with Argumentation (PBLA). The argument chosen for intervening in PBL is Taoulmin Argumentation Pattern (TAP). TAP was chosen to intervene in PBLA because TAP contained elements such as data, backing, warrant, qualifier, rebuttal, and

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claim, which required accuracy in compiling it, so it was very suitable to practical work skills of critical thinking to the fullest. The model is thought to help students use their critical thinking skills to start increasing their life-long learning skills: problem solving, verbal and written communication, working as a group and enhancing leadership. PBLA model has the characteristic of genuine problems that generate a conflict with the students in the forms of ill-structured, ill-defined or open-ended stimuli within the learning activity; these matters involve supports and justifications along with proof.

PBLA Characteristics: (1) Training is achieved by paying attention to initial awareness of the students. Teacher asks or gives a picture to students of the previous learning material. The teacher provides experience as needed if students do not have sufficient initial knowledge. (2) Integrating learning with situations that are often experienced by students in everyday life. This is done by providing tasks and things relevant to the application of science in daily life. (3) Learning begins with the identification of problems raised by the teacher. The problem raised can be an ill defined problem. (4) Claim answers given to problems must be prepared through TAP based on evidence in the form of data obtained and accompanied by justification through scientific reasoning processes. (5) Students are facilitated and encouraged to interact with other students when constructing claim answers and answering problems. (6) Answers to problems that have been prepared by students must be evaluated and validated through discussion activities. (7) Discussion activities are carried out by involving social activities through dialogue activities, collaborative group discussions, students are involved in the activity of asking questions, preparing warrant to support claims in order to build of argumentation and explanations and propose, criticize, and evaluate ideas among students.

PBLA syntax has five phases, namely problem identification and motivation, organization and investigation, argumentation building, argumentation session, and evaluation-reflection. These five phases are sequential, must not be reversed. Phase 1, problem identification and motivation. The teacher's activities motivate students 'curiosity, explore students' interests, relate old experiences and what will be learned, inform the objectives of the lesson and describe the learning needs, and provide authentic problems.

Phase 2, organization and investigation. Teacher activities encourage students to gather information, look for theories and strategies for developing skills of critical thinking, tax breaks or worksheets, form groups of 4-5 students, and conduct experiments in the order of activities formulating problem formulation, constructing hypotheses, determining control variables - manipulation variables - response variables, formulate operational definitions, prepare inquiry tools, design investigations, and record observations.

Phase 3, argumentation building. Teacher helps students analyze data, interpret data analysis results and create responses through argumentation by compiling according to the TAP, namely establishing recognition as a solution to the problem accompanied by data, evidence, support, qualifications, and refutation (Toulmin, 2003).

Phase 4, argumentation session. Teacher activities provide opportunities for students to convey their ideas / answers that have been prepared through TAP, respond to questions, submit evidence to their knowledge, measure the advantages of the exchange of ideas, and share alternative views or ideas.

Phase 5, evaluation-reflection. Teacher activities guide students to conclude from the learning activities that have been carried out, provide opportunities for students so that students provide feedback on the entire learning process, and carry out an evaluation of the learning material provided.

**Research Problem**

This research uses PBLA in learning science subject matter of temperature and its change and heat and displacement. Formulation of problem is how is validity and effectiveness of PBLA to develop skills of critical thinking for students in SMP? Purpose of study was to determine validity and effectiveness of PBLA to improve skills of critical thinking for students in SMP. PBLA meet valid criteria if validity of content and validity of construct of results of assessment of validators are valid and reliable. The PBLA model meets the effective criteria if students increase their skills of critical thinking since mastering with PBLA at $\alpha$ =

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5%, average n-gain is moderate, and the difference does not differ for the two classes of research.

Focus Research

Focus of research is to build PBLA model so that it is feasible to increase skills of critical thinking. This model is said to be feasible if it meets valid, practical and effective criteria. Focus of research are validity and effectifeness of PBLA. Validity in terms of validity of content and validity of construct. While the effectiveness of PBLA in terms of increasing skills of critical thinking, level of improvement, and the similarity of improvement for the two classes.

## METHOD

The current study is catagorized Research and Development (R&D). Sugiyono (2014) states R & D is a research that tests the effectiveness of the produced products. The study seeks to develop a valid and effective product for the PBLA model (Nieveen, 1999) to incresae skills of critical thinking for students in SMP. PBLA's operational form is a learning tool called Syllabus, Lesson Plan (LP), Student Activity Sheet (SAS), Teacher's Book and Student's Textbook (ST), and instruments for assessing critical thinking skills. The PBLA model refers to Wademan 's development research model design (Plomp & Nieveen, 2013) namely (1) identification of problem, (2) idetify tentative product and design principles, (3) temporary theories and product, (4) initial prototyping product assesment and theoris, and (5) problem solving and development theories.

In accordance with the needs of the five stages are summarized into three stages, namely: (1) introduction, consisting of design and learning (2) development of the model (product), consisting of the preparation of learning temperature and its changes, as well as heat and displacement, small-scale trials and improvement (3) implementation of learning and research design testing. In this third stage, to see the effectiveness of research product in the form of PBLA models to increase students' critical thinking skills in seventh grade junior high school.

The implementation of this research in the even semester knows the 2016/2017 lessons and takes 18 weeks. The subject of this learning language is temperature and its changes and heat and development. This study wants to see validity and effectiveness of using PBLA in increasing skills of critical for students in SMP.

### Research Sample

Study will examine the learning process with PBLA science subjects the subject of temperature and its changes and heat and disruption in junior high school. The research sample used was 52 students from a population of 7th grade students a total of 130 SMN 1 Galur students, divided into two classes, each with 26 students. Determination of the sample by random sampling technique of clasters. This technique is carried out because it is considered to be simpler, takes little time and is efficient (Fraenkel et al, 2012). All students are divided into 5 classes, namely classes 7A, 7B, 7C, 7D, and 7E. From the sampling technique selected classes 7A and 7C, each class of 26 students.

### Procedures

This study has been categorized as a pre-experimental study with a pretest-posttest design identified as: O1 X O2 (Fraenkel et al, 2012). The treatment of the two classes of students in the study sample was to provide pretests before learning with PBLA (O1) and posttests after learning with PBLA was completed (O2). The learning process uses PBLA (X) using validated learning tools. Learning tools include learning implementation plans (LP), student textbooks (BTS), student activity sheets (SAS), and assessment sheets (AS).

### Analysis of Data

The validity of PBLA is based on the mean of validator ratings, where the formula is $V_{average} = (V_1 + V_2 + V_3)/3$, where V is the validator's score (Kusumawati et al, 2015). BPLA reliability is determined by the formula: R = [matching frequency between evaluators / (matching frequency between evaluators + mismatch frequency between evaluators)] x 100%. Table 1 shows the PBLA validator evaluation criteria.

Table 1. Validator evaluation criteria

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| Score | Category | Inforamation |
|---|---|---|
| 3.25<P≤4.00 | Very valid | Can be used without revision |
| 3.20<P≤3.25 | Valid | Can be used with minor revision |
| 1.75<P≤3.20 | Less valid | Can be used with major revision |
| 1.00<P≤1.75 | Not valid | Cannot be used & beed consultation |

Source:Kusumawati et al, 2015

The effectiveness of PBLA for enhancing student learning was evaluated in the following order with pre-test results: (1) paired t test or Wilcoxon for non-parametric tests (Gibbons & Chakraborti, 2011); (2) determine the n-gain by the equation: n-gain = (posttest - pretest)/(100-pretest), with criteria: (a) if n-gain ≥ .70 (high), (b) if .30 < n-gain < .70 (moderate), and (c) if n-gain n-gain ≤ .30 (low) (Sudayana, 2016; Limatahu et al , 2018); and (3) the two average similarity test or the Mann Whitney U-test for non-parametric format (Gibbons & Chakrabaroti, 2011).

## RESEARCH RESULT

After the PBLA model as a hypothetical to inrease skills of critical thinking for students in SMP is completed, next step is to carry out a model trial. The trial was conducted at SMP N 1 Galur for the even semester of the 2016/2017 school year within 18 weeks for SMP science subjects in theme of temperature and measurement as well as heat and changes. This study wants to review the analysis of validity and effectiveness of PBLA, by analyzing the impact of PBLA teaching on increasing the skills of critical thinking for students in SMP.

Validation process by three validators who are experts in science education towards the PBLA model is carried out with discussion in Focus Group Discussion (FGD). FGD talked the learning tools as a completeness of the PBLA model, which included Syllabus, Lesson Plan, Student Texbooks (TS) and Student Activity Sheet (SAS). The results of the assessment of expert validators during the FG and validation process can be found in Table 2.

**Tabel 2**. Validity and reliabilty score of PBLA

| Item | Content validity | | | | Construct validity | | | |
|---|---|---|---|---|---|---|---|---|
| | Validity | | Reliabilty (%) | | Validity | | Reliabilty (%) | |
| 1. PBLA Model | 3.5 | Valid | 77.10 | Reliabel | 3.3 | Valid | 77.67 | Reliabel |
| 2. Syllabus | 3.5 | Valid | 87.60 | Reliabel | 3.3 | Valid | 87.50 | Reliabel |
| 3. LP | 3.5 | Valid | 87.50 | Reliabel | 3.3 | Valid | 87.80 | Reliabel |
| 4. ST | 3.5 | Valid | 89.80 | Reliabel | 3.3 | Valid | 87.60 | Reliabel |
| 5. SAS | 3.3 | Valid | 87.50 | Reliabel | 3.3 | Valid | 87.10 | Reliabel |

(LP:Lesson Plan; ST: Student Textbooks; SAS: Student Activity Sheets)

Table 2 shows that the PBLA model, which includes: Syllabus, LP, ST and SAS, each accurate and reliable in content and in design, is valid and reliable in terms of content and structure as well as the learning resources supporting PBLA's model. Next, a PBLA model was tested to see the model's viability. The implementation of the PBLA model is seen from observers that observing the learning implementation in each lesson plan by teacher of model. Teacher of model in the study was a teacher in the field of science studies from the school of research and was observed by 2 observers who had been trained and involved in discussions about how to implement the PBLA model. The observer is in charge of observing the implementation of lesson plans, students activities, and constraints during learning process. Implementation of SIP includes the introduction, core and conclusions, as well as classroom atmosphere and time management. Implementation of learning plan is observed by giving a score of 1 – 4 (Ratumanan & Laurens, 2011). Discussions between researchers and the model teacher are conducted after learning is finished to receive input from the observer. Figure 1 shows the consistency of the PBLA.

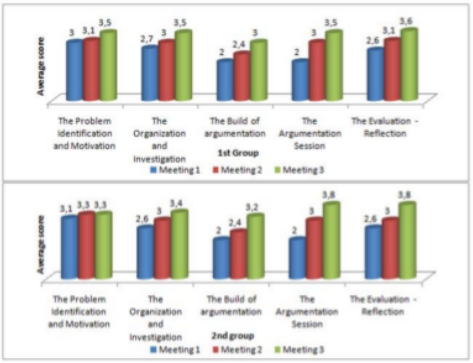


**Figure 1.** Mean viability of the PBLA model

Figure 1 shows that implementation of PBLA model showed and increase in each meeting. The argumentation building phase and the argumentation session have the lowest score at the first meeting. These phases have increased at the second and third meetings, but the phase of building an argument has difficulty in the learning process. The average reliability for the first meeting was 96.36%, for the second meeting

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96%, and for the third meeting 94.4%, so that the total reliability was 95.59% (very good category).

Furthermore, to see the effectiveness of learning done with the PBLA model in group 1 and group 2, in six times learning with PBLA, where each learning is preceded by a pretest and ends with a posttest. The pretest and posttest scores during the study for group 1 and group 2 are shown in Figure 2 and Figure 3.

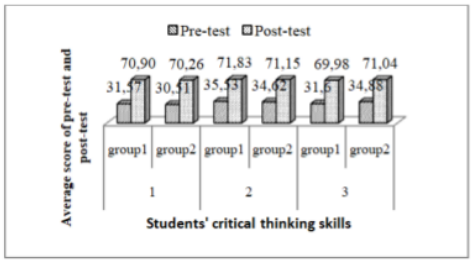


**Figure 2.**. Average pretest – posttest scores of skills of critical thinking of students for 1st and 2nd groups at 1st to 3rd meetings.

Figure 2 shows that an average score between pretest – posttest of skills of critical thinking of students for the 1st and 2nd groups at 1st to 3rd meeting increased.

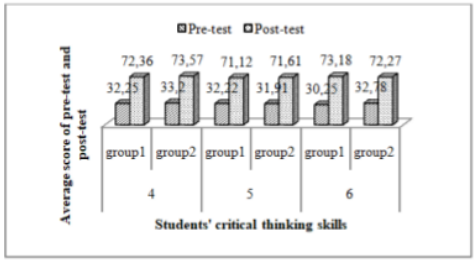


**Figure 3.** Average pretest - posttest score of skills of critical thinking of students for groups 1 and 2 in 4th, 5th, and 6th learning processes.

The mean scores of pretest-posttest skills of critical thinking of students in group 1 and group 2 always increase in meetings 4, 5, and 6, as shown in Figure 3.

Furthermore, the normality of the pretest – posttest scores with the Kolmogorov-Smirnov test, the results are obtained that all are normally distributed. Increased skills of critical thinking for students ere analyzed using paired t-tests. Paired t-test results were obtained after skills of critical thinking for students test data met normality test and normal distribution as shown in Table 3.

**Table 3.** Result of T-test results for skills of critical thinking test data.

| Pair | N | Mean | Std. Error Mean | t | df | p |
|---|---|---|---|---|---|---|
| Pair 1 (LP1) | 26 | 51.24 | .183 | -9.013 | 25 | .0001 |
| Pair 2 (LP1) | 26 | 50.39 | .156 | -10.579 | 25 | .0001 |
| Pair 3 (LP2) | 26 | 53.68 | .185 | -8.505 | 25 | .0001 |
| Pair 4 (LP2) | 26 | 52.88 | .194 | -7.931 | 25 | .0001 |
| Pair 5 (LP3) | 26 | 50.79 | .158 | -15.126 | 25 | .0001 |
| Pair 6 (LP3) | 26 | 52.96 | .183 | -7.336 | 25 | .0001 |
| Pair 7 (LP4) | 26 | 52.30 | .178 | -12.526 | 25 | .0001 |
| Pair 8 (LP4) | 26 | 53.38 | .169 | -13.182 | 25 | .0001 |
| Pair 9 (LP5) | 26 | 51.67 | .216 | -15.842 | 25 | .0001 |
| Pair 10 (LP5) | 26 | 50.76 | .159 | -15.951 | 25 | .0001 |
| Pair 11 (LP6) | 26 | 51.71 | .136 | -13.283 | 25 | .0001 |
| Pair 12 (LP6) | 26 | 52.52 | .194 | -12.520 | 25 | .0001 |

From table 3, information is obtained that all the learning processes conducted by group 1 and group 2 are negative t value with p <.05, which means that the posttest score is always greater than the pretest score. The level of skills of critical thinking after learning with PBLA is higher than the state in skills of critical thinking before learning with PBLA. The synthesis is, students experience an increase in skills of critical thinking after learning with PBLA at a significance level α = 5%.

To find out the improvement in critical thinking skills for the two groups of trials after being considered normal and homogenous, an average similarity test was conducted using an independent t-test. Complete details are mentioned in table 4.

**Table 4**. Data on increasing skills of critical thinking for students from the rising of the independent t-test.

| dependent t-test | | | | | | |
|---|---|---|---|---|---|---|
| | | Sum of Squares | df | Mean Square | F | Sig. |
| Gain LP1 | Between Groups | .0001 | 1 | .0001 | .0001 | 1.000 |
| | Within Groups | 20.923 | 50 | .418 | | |
| | Total | 20.923 | 51 | | | |
| Gain LP2 | Between Groups | .019 | 1 | .019 | .019 | .891 |
| | Within Groups | 50.962 | 50 | 1.019 | | |
| | Total | 50.981 | 51 | | | |
| Gain LP3 | Between Groups | 13.000 | 1 | 13.000 | 14.696 | .061 |
| | Within Groups | 44.231 | 50 | .885 | | |
| | Total | 57.231 | 51 | | | |
| Gain LP4 | Between Groups | .019 | 1 | .019 | .020 | .888 |
| | Within Groups | 48.038 | 50 | .961 | | |
| | Total | 48.058 | 51 | | | |
| Gain LP5 | Between Groups | 7.692 | 1 | 7.692 | 6.821 | .072 |
| | Within Groups | 56.385 | 50 | 1.128 | | |
| | Total | 64.077 | 51 | | | |
| Gain LP6 | Between Groups | 4.327 | 1 | 4.327 | 4.845 | .082 |
| | Within Groups | 44.654 | 50 | .893 | | |
| | Total | 48.981 | 51 | | | |

Data in increasing skills of critical thinking can be seen in table 4. The table shows a significant improvement between group 1 and group 2. All meetings, both Group 1 and Group 2, are of greater significance than.05 (sig. > .05). This indicates, there is a significance level of 5 % improvement in skills of critical thinking after students undergo the learning process with PBLA.

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## DISCUSSION

### PBLA validity

The learning model is very much determined by content and construct. Therefore the validity of a learning model is determined by the content validity and product validity, and this is largely determined by the characteristics, needs and novelty of the learning model. To determine this validity is tested according to the criteria, in the sense that the test results have alignment with predetermined criteria. To get the validity of PBLA, it was conducted with FGD together with science education experts. This is done to assess the quality of the product, in this case PBLA (Murgado-Armanteros et al, 2012). Table 2 clearly shows the FGD results related to the validity of the PBLA model and its learning tools, such as syllabus, LP, ST, and SAS. The results of the FGDs showed that the PBLA model and its learning tools were valid and could be relied upon for learning. In theory, a product quality can be said to be accurate if it is known that at least the average score for the two reviewers is 2.75 (Ratumanan & Laurents, 2011). This research produces content validity of 3.5 and construct validity of 3.3. The conclusion can be drawn that the PBLA model has valid contents and constructions. This also means that the syllabus, LP, ST, and SAS are all valid, and in accordance with the statement of Plomp & Nieveen (2013) which says that a good product if the content is able to describe the needs, novelty, and consistency is maintained between the components of the model and the existence of theoretical support and practice. The accuracy of the PBLA model needs to be tested to be suitable, reliable and regularly applicable. While Sarstedt & Mooi (2014) said, reliability of the product is considered reliable if internal consistency and reliability are respected.The model can be relied on if its reliability is at least 75% (Borich, 1994). Because the FGD results of the PBLA model are above 75% reliability, it can be said that the PBLA model has high reliability.

The development of this PBLA model includes learning tools that include syllabi, PL, ST, and SAS which theoristically and empirically have new features based on learning needs, and have consistency between learning components (Plomp & Nieveen, 2013). It learning resource is structurally written and can also be used for the learning and growth of skills of critical thinking. (Retnowati et al, 2020).

Thus, this valid PBLA model can be a reference to increase skills of criticsl thinking for students in SMP. The presence of a model will allow researchers and faculty / pedagogues to conduct their learning work in compliance with the relevant regulations has been mentioned by Seechaliao et al ( 2012). Kimbell & Stables (2007) revealed, a valid model can be used as a reference for teachers in carrying out their assignments.

The synthesis, a true PBLA, is an alternate approach that may develop skills of critical thinking for students.

### PBLA effectiveness

A successful model of learning must be valid, practical and effective. It is claimed that the learning model is effective because it complies with the learning plan (Honebein, 2015). In other words, learning is effective if the learning done by the teacher is able to achieve student learning goals. This can be achieved when the teacher in implementing the learning process has the right strategy in delivering teaching material to students, able to combine theory and practice in learning. In order for the teacher's learning objectives to be carried out effectively, then: (1) the teacher must have clear objectives; (2) teachers must have clear knowledge and understanding of their learning tools such as syllabus, LP, ST, SAS and assessment sheets, all of which have no validity doubts; (3) teachers must be able to carry out learning and create an open and positive learning environment (Hu et al, 2013); active students in the learning process, teachers / schools provide the facilities and infrastructure needed in learning, especially laboratories, computers (Betty, 2013); (4) an increase in student achievement in this case an increase in skills of critical thinking (Zimmerman & Shunk, 2012). Activity theory states that if students actively participate in the learning process eating will improve learning outcomes (Jatmiko et al, 2016). The learning outcomes in this study are increased skills of critical thinking after students experience the learning process with PBLA.

To find out how to develop skills of critical thinking, n-gain test was performed based on the pretest-posttest skills of critical thinking applied to the student trials, which carried out the learning

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process with PBLA on the material temperature and its changes as well as heat and displacement. In this study, the acquisition of pretest scores was always lower than the posttest scores, as seen in Figure 1and Figure 2. In the first, second, third, and fourth, fifth, sixth consecutive learning process: for group 1 the pretest score was 30.57; 35.53; 31.5; and 32,25; 32.2; 30.25 and for group 2 the pretest score was 30.51; 34.62; 34.88 and 33.20; 31.91; 32.78.

This low pretest result where the range of scores from 1 to 100, shows that students do not have skills of critical thinking, because they have not experienced the learning process with the PBLA model. Kurniasih's research (2010) shows that learning science is relatively more difficult and complex so it needs to be handled in a systematic and structured way. Problem solving and skills of critical thinking are low for SMP. The results of preliminary research conducted on 62 students in SMPN Wates 5 showed that some students were able to convey memorized material and knowledge delivered by the teacher but were not yet able to work on problems that were analysis of the graphics or images presented. This happens because students are accustomed to thinking verbally and concretely while less trained to think abstractly and critically. As a result, students find it difficult to ask argumentative questions (Thobroni & Mustofa, 213). Even though questioning skills are a condition for the emergence of critical thinking that is expressed verbally.

After learning process with PBLA, the acquisition of skills of critical thinking scores increased. This matter can show in Figure 1 and Figure 2 in the posttest score respectively: for group 1 the posttest score is 70.90; 71, 83; 69.98; and 72.36; 71, 12; 73.18; and group 2, the posttest score was 70.26; 71,15; 71.04 and 73.57; 71.61; 72.27. This means, students have skills of critical thinking after experiencing the learning process with the PBLA on subject of temperature and change and heat and displacement.

Next, the n-gain of each learning process is reviewed from the learning process 1, 2, 3, 4, 5, 6 in a row: for groups 1 the n-gain: 0.58, 0.56, 0.56, 0.59, 0.57, 0.57, 0.62 and for groups of 2 n-gain: 0.57, 0.55, 0.56, 0.60, 0.58, 0.59. From n-gain it can be seen that increase in skills of critical thinking after students experience a learning process with PBLA models in the criteria of being (.3 $\leq$ n-gain $\leq$ 7.7) (Hake, 1998).

To find out the consistency and significance of the increasing in skills of critical thinking after students experience a learning process with PBLA in subject of temperature and its changes and heat and displacement as shown in Table 3 and Table 4. Indicators of increasing skills of critical thinking are analysis, synthesis and evaluation or Bloom's Taxonomy before being revised (Bloom, 1956). In implementing learning, students are asked to look for everyday problems that are authentic, open, and irregular (Indriyantni et al, 2014). The findings are then revealed in the learning activities, at the beginning of the lesson (phase 1). The findings are then used as material for investigation by a group of students by making the title of the inquiry, formulating the problem, hypothesizing, determining control-manipulation-response variables, making operational definitions, searching for tools and material for inquiry, setting up investigation tools, carrying out investigations, recording inquiry data (phase 2). The next step, students are asked to evaluate the results of the investigation and arrange arguments (phase 3), conduct discussions between groups to get input and responses to draw conclusions from the investigation (phase 4). After that, it ends with drawing final conclusions by getting direction from the teacher, and inputs to the learning process that has been done (phase 5). With this PBLA learning experience, students are trained to analyze, analyze, and evaluate science problems (Bradford, 2015), of course by using the right syllabus, LP, ST, and SAS, learning equipment and a good learning environment that will provide good learning experience (Barkerci et al, 2011). PBLA learning is also able to arouse curiosity, motivation, perseverance, accuracy, cooperation, communication.

This PBLA model uses a syntax that has been prepared in accordance with its learning objectives, namely to increase skills of critical thinking for studeents in SMP. Theoretical and empirical support from this syntax comes from several recent studies such as: (1) Barrett et al (2019) which says that the effectiveness of a learning occurs if there is an availability of learning infrastructure and facilities, active student participation and feedback from the user community. (2) effective teachers in the sense of teachers who know and are able to arouse

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students' curiosity, guide students to carry out investigations, understand curriculum and its implementation and understand how to deal with the complexity of learning (Darling-Hammond et al, 2020). (3) organizing various knowledge for the provision of inquiry in social aspects for the benefit of social interaction in order to help students get immediate ideas in daily life. In this way students become more active in class, discuss, so that they can maintain their study habits (Csikszentmihalyi, 2014).

The application of PBLA models to increase these skills of critical thinking also received support from learning theories such as constructivism, scafolding and behavior learning theories. There are two constructivist theories, namely individual and social constructivists. Supardan (2016) revealed that individual constructivist often explain how individuals onstruct knowledge in their mainds. The information processing approach to learning regards the human mind as a symbol processing system. This system convert sensory input into symbol structures (propositions, images, or schemes), and then processes (reheares or elaborate) the symbol structure so that knowledge can be stored in memory and retrived. The outside world is considered as an input source, but once the sensation is perceived and enters working memory, the important task is assumed to occur in head of the individual. Piaget (Arends, 2012) said that every student at any age is actively engaged in the process of information acquisition and the creation of his or her own knowledge. The knowledge process that is taking place is top-down, students begin with complicated problems that need to be overcome and then solve or discover (with the aid of the teacher) the practical skills they need. So effective learning requires an understanding of how to make information easily accessible to students so that students can change information and apply it outside of learning (Slavin, 2006). While social constructivist theory holds that students in building their knowledge must go through social interaction with the teacher or other students, which in this study was conducted with small group discussions and panel discussions in the argumentation session (phase 4). Scafolding theory also plays a role in PBLA learning because students are also given complex tasks with gradual assistance to problem solving (Slavin, 2006). While behavioral theory of learning also plays a role in terms of conditioning students in carrying out activities of learning by observing the behavior and explanations of others.

## CONCLUSION

In conclusion, PBLA is an appropriate model to increase skills of critical thinking for students in science learning in thema the temperature and change as well as heat and displacement in SMP. Specifically, the PBLA model has a validity of 3.35 and a reliability of 77.10% in improving skills of critical thinking for students, which means both are in the medium criteria. As well. PBLA is effective for increasing the skills of critical thinking for students in SMP at a significant level $\alpha = 5\%$, where the average increase in skills of critical thinking is at moderate criteria, and there is a similarity in increasing the skill of critical thinking of the two test groups.

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