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PROBLEM-BASED LEARNING WITH ARGUMENTATION AS A HYPOTHETICAL MODEL TO INCREASE THE CRITICAL THINKING SKILLS FOR JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

The Problem-Based Learning with Argumentation (PBLA) model is a development model of Problem-Based Learning (PBL) added to the Toulmin Argumentation activity to increase the critical thinking skill in junior high school. The research aims to determine the feasibility of PBLA in terms of its validity and effectiveness. The research samples are two groups of students (class 1 and class 2) with 26 students in each class. 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 were obtained through validity sheets and analyzed through expert agreement. PBLA effectiveness data was obtained through critical thinking skill tests and analyzed by paired t-test, n-gain, and two-average similarity test. The results showed that the content validity and the construct validity categorized as valid with a score of 3.5 and 3.3. The reliability scores obtained are 77.10% and 77.67%. The critical thinking skill data showed a significant increase in critical thinking skill at $\alpha = 5\%$, the average n-gain was categorized high, and there was a similarity in increasing critical thinking skills for the two classes. In conclusion, PBLA is effective in increasing critical thinking skills for junior high school students.

Keywords: PBLA; critical thinking skills; junior high school

INTRODUCTION

Critical thinking skills are one of the essential skills for students to live in the 21st century, where life phases enter the era of digital revolution 4.0. The life in this era is characterized by skills of critical thinking and problem-solving, the 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., 2015) by problem-solving and decision-making (Carter et al., 2016). Bloom et al. (1956) say that the most critical analytical skills are analyzes (C4), synthesis, and assessments/evaluation (C6). Analyzing involves the ability to evaluate and separates knowledge or systems in small pieces so that patterns or interactions are identified, the causes and consequences of a complicated 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, and others using appropriate parameters or established principles, to assess their performance or merit.

Seeing the above definition, skills of critical thinking are essential for education at all levels (Hudha & Batlolona, 2017), of course, following the level of thinking. It is essential to prepare future generations who can answer the challenges

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of an increasingly complex and rapid era of development that can change the rapid development of society (Gumus et al., 2013). The Government of Indonesia Republic through Decree of Minister of Education and Culture of Indonesia Republic No 68 of 2013 concerning the structure of junior high school curriculum, states the need to change passive learning into critical get critical learning outcomes.

The critical thinking skills for students are still weak in the field. Research on critical thinking skills 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 teach critical thinking skills (Choy & San Oo, 2012). However, in reality, most teachers cannot teach critical thinking skills effectively because of their low teaching 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 critical thinking skills for students?

One learning model in school today that has been believed to teach critical thinking skills for students, namely by using a model of Problem Based Learning (PBL), developed by Arends (2012). The reality on the ground shows that the PBL model always have weaknesses, especially students are still weak in giving argumentation (Batdi, 2014). Sockalingam & Schmidt (2011) conducted a study with 34 samples using the PBL model. The results showed the weaknesses of PBL, which is 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 will have difficulty in problem-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 skills to investigate and collaborate with students to solve problems was still low. These two obstacles showed that when students have adversity understanding basic concepts, students have difficulty in arguing.

One of the essential learning goals is to increase critical thinking skills. With one's critical thinking skills, one can solve complex problems. Critical thinking skills 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 critical thinking skills to their students. Thus, this research is developing a new model that can train students with critical thinking skills. 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 Toulmin Argumentation Pattern (TAP). TAP was chosen because it contained elements such as data, backing, warrant, qualifier, rebuttal, and claim, which required accuracy in compiling it, so it was very suitable to practical work critical thinking skills 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 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 the initial awareness of the students. The teacher asks or gives a picture to students of the previous learning material. The teacher provides an 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. It 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 ill-defined. (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 or collaborative group discussions. Students are involved in the activity of asking questions, preparing a 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: 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 is problem identification and motivation. The teacher's activities are to 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 is the phase of organization and investigation. Teacher activities are to encourage students to gather information, look for theories and strategies for developing critical thinking skills, 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 is the argumentation building. The 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 is the 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 is evaluation-reflection. Teacher activities are to 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 used PBLA in learning science about temperature and heat. The problem formulation is how the validity and effectiveness of PBLA are to develop critical thinking skills for students in SMP? The purpose of the study was to determine the validity and effectiveness of PBLA to improve critical thinking skills for junior high school students. PBLA meets valid criteria if the content validity and the construct validity of assessment results from validators are valid and reliable. The PBLA model will meet the effective criteria if students increase their critical thinking skills since mastering with PBLA at $\alpha = 5\%$, average n-gain is moderate, and the difference does not differ for the two classes of research.

Focus Research

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

METHODS

The current study is categorized as Research and Development (R&D). Sugiyono (2015) states that R&D is research that tests the effectiveness of the products. The study seeks to develop a valid and effective product for the PBLA model (Nieveen, 1999) to increase critical thinking skills for junior high school students. 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 the problem, (2) identify tentative product and design principles, (3) temporary theories and product, (4) initial prototyping product assessment and theories, and (5) problem solving and development theories.

Following the needs of the five stages are summarized into three stages, namely: (1) introduction, consists of designing and learning (2) model development (product), consists of the preparation of learning temperature and its changes and heat transfer, small-scale trials and improvement (3) implementation of learning and research design testing. The third stage is to see the effectiveness of research products, in the form of PBLA models to increase students' critical thinking skills in the seventh-grade junior high school.

The implementation of this research was in the even semester 2016/2017 school year within 18 weeks. The subject is temperature and heat. This study wants to see the validity and effectiveness of using PBLA in increasing critical skills for junior high school students.

Research Sample

The study will examine the learning process with PBLA in learning science about temperature and heat in junior high school. The research sample was 52 students from a population of 130 seventh-grade students of SMPN 1 Galur. The samples are divided into two classes, 26 students in each class. The cluster random sampling

technique determined samples. 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 five classes: 7A, 7B, 7C, 7D, and 7E. From the sampling technique, the selected classes are 7A and 7C, with 26 students in each class.

Procedures

This study was categorized as a pre-experimental study with a pretest-posttest design identified as O1 X O2 (Fraenkel et al., 2012). The treatment in the two classes of students was to provide pretests before learning with PBLA (O1), and posttests after learning with PBLA was completed (O2). The learning process used PBLA (X) using validated learning tools. Learning tools included lesson plan (LP), student textbooks (ST), 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

Score	Category	Information
3.25<P≤4.00	Very valid	Can be used without revision
3.20<P≤3.25	Valid	Can be used with mino 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, 2014); (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) (Sundayana, 2014; Limatahu & Prani , 2018); and (3) the two average similarity test or the Mann Whitney U-test for non-parametric format (Gibbons & Chakraborti, 2014.

RESULTS AND DISCUSSION

After the PBLA model as hypothetical to increase critical thinking skills for junior high school students is completed, the 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 junior high school science subjects about temperature and heat. This study wants to review the analysis of the validity and effectiveness of PBLA by analyzing the impact of PBLA teaching on increasing the critical thinking skills for junior high school students.

The 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 about the learning tools as the completeness of the PBLA model, which included Syllabus, Lesson Plan, Student Textbooks (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 Reliability Score of PBLA

		Content Validity				Construct Validity			
	Item	Validity		Reliability (%)		Validity		Reliability (%)	
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, is accurate and reliable in content and 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 PBLA model implementation is seen from observers that observing the learning implementation in each lesson plan by the teacher of the model. The teacher of the model in this study is a science teacher from the school of research. The teacher was observed by two 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 the learning process. Implementation of SIP includes the introduction, core, and conclusions, as well as classroom atmosphere and time management. The implementation of a 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 to receive input from the observer. Figure 1 shows the consistency of the PBLA.

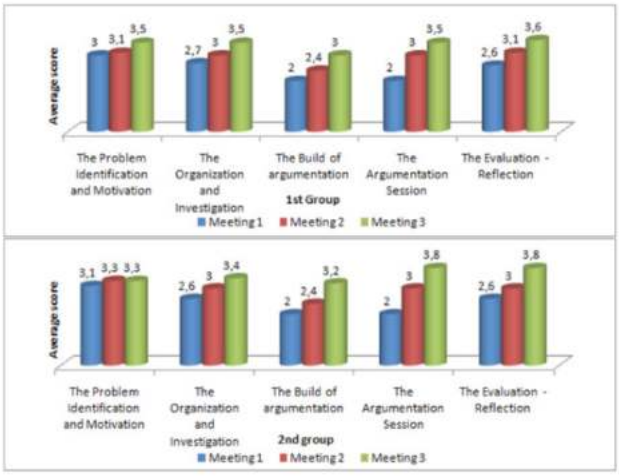

Figure 1. Mean viability of the PBLA Model

Figure 1 shows that the implementation of the PBLA model showed an 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 96%, and 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.

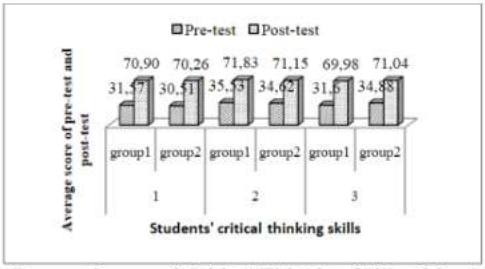

Figure 2. Average Pretest–Posttest Scores of Critical Thinking Skills of Students for First and Second Groups at First to Third Meetings

Figure 2 shows that an average score between the pretest-posttest of critical thinking skills of students for the first and second groups at first to third meeting increased.

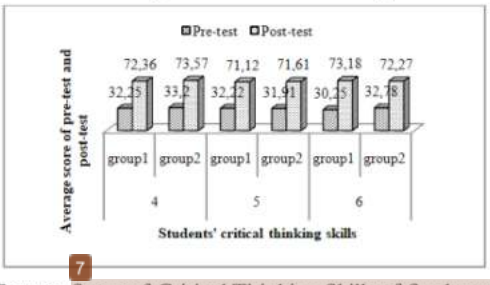

Figure 3. Average Pretest-Posttest Score of Critical Thinking Skills of Students for Groups 1 and 2 in 4th, 5th, and 6th Learning Processes

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

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

Table 3. Result of T-Test Results for Critical Thinking Skills 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 obtained is that all learning processes conducted in group 1 and up 2 are negative t-value with $p < .05$, which means that the posttest score is always higher than the pretest score. The level of critical thinking skills after learning with PBLA is higher than before learning w PBLA. The synthesis is, students experience an increase in critical thinking skills after learning with PBLA at a significance l of $\alpha = 5\%$.

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

Table 4. Data on Increasing Critical Thinking Skills 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	0.19	.019	.891
	Within Groups	50.962	50	1.019		
	Total	50.981	51			
Gain LP3	Between Groups	13.000	1	13.000	14.696	0.61
	Within Groups	44.231	50	.885		
	Total	57.231	51			
Gain LP4	Between Groups	.019	1	0.19	.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	0.82
	Within Groups	44.654	50	.893		
	Total	48.981	51			

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

PBLA Validity

The learning model is very much determined by content and construct. Therefore, the validity of the learning model is determined by content validity and product validity, and this is determined mainly by the characteristics, needs, and novelty of the learning model. To determine if the validity is tested according to the criteria, which means that the test results have alignment with predetermined criteria. The test was conducted with FGD with science education experts to get the validity of PBLA. It is done to assess the product quality, in this case, PBLA (Murgado-Armenteros et al., 2012; Safaruddin et al., 2020). 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 reliable for learning. In theory, product quality can be considered as accurate if it is known that at least the average score for the two reviewers is 2.75 (Ratumanan & Laurens, 2011). This research produces 3.5 of content validity and 3.3 of construct validity. The conclusion is that the PBLA model has valid content and constructions. It also means that the syllabus, LP, ST, and SAS are all valid, and under the statement of Plomp & Nieveen (2013) which says that a product is useful if the content can describe the needs, novelty, and consistency 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). The FGD result of the PBLA model of reliability is above 75%, so the PBLA model has high reliability.

The development of this PBLA model includes learning tools that include syllabus, LP, ST, and SAS, which theoretically and empirically

have new features based on learning needs, and have consistency between learning components (Plomp & Nieveen, 2013). Its learning resource is structurally written and can also be useful for the learning and growth of critical thinking skills. (Retnowati, 2020).

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

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

PBLA Effectiveness

A successful model of learning must be valid, practical, and effective. The learning model is claimed effective because it complies with the learning plan (Honebein & Honebein, 2015). In other words, learning is effective if the teacher can achieve student learning goals. It 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 explicit 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 (Beatty, 2013); (4) an increase in student achievement, in this case, an increase in critical thinking skills (Zimmerman & Schunk, 2011. Activity theory states that if students actively participate in the learning process, it will improve learning outcomes (Jatmiko et al., 2016). The learning outcomes in this study are increased critical thinking skills after students experience the learning process with PBLA.

The N-gain test was performed based on the pretest-posttest critical thinking skills applied to the student trials to find out how to develop critical thinking skills, which carried out the learning process with PBLA on the material temperature and heat. In this study, the acquisition of pretest scores was always lower than the posttest scores, as seen in Figure 1 and 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 critical thinking skills, because they have not experienced the learning process with the PBLA model. Kurniasih's research (2010) shows that learning science is relatively more challenging and complex, so it needs to be handled in a systematic and structured way. Problem-solving and critical thinking skills are low for junior high school. The results of preliminary research conducted on 62 students in SMP N 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 in the form of analysis of the presented graphics or images. It 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 (Mustofa & Thobroni, 2011). Questioning skills are a condition for the emergence of critical thinking that is expressed verbally.

After the learning process with PBLA, the acquisition of critical thinking skills 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. It means students have critical thinking skills after experiencing the learning process with the PBLA on the subject of temperature and heat.

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 critical thinking skills after students experience a learning process with PBLA models in the criteria of being ($.3 \leq$ n-gain ≤ 7.7) (Hake, 1998).

To find out the consistency and significance of the increase in critical thinking skills after students experience a learning process with PBLA in the subject of temperature and heat as shown in Table 3 and Table 4. Indicators of increasing critical thinking skills are analysis, synthesis, and evaluation, or Bloom's et al Taxonomy before

being revised (Bloom et al., 1956). In implementing learning, students are asked to look for daily problems that are authentic, open, and irregular (Indriyatni et al., 2015). The findings are then revealed at the beginning of the learning activities (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). In 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 conclude the investigation (phase 4). It ends with concluding by getting direction from the teacher and inputs to the learning process (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 (Bakırcı et al., 2011). PBLA learning is also able to arouse curiosity, motivation, perseverance, accuracy, cooperation, communication.

This PBLA model used a syntax that has been prepared under its learning objectives, namely to increase critical thinking skills for junior high school students. Theoretical and empirical support from this syntax comes from several recent studies, such as (1) Barrett et al. (2019). They say that the effectiveness of 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 can arouse 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 critical thinking skills also received support from learning theories such as constructivism, scaffolding, and behavioral learning theories. There are two constructivist theories, namely individual and social constructivists. Supardan (2016) revealed that individual constructivist often explains how individuals construct knowledge in their minds. The information processing approach to learning regards the human mind as a symbol processing system. This system converts sensory input into symbol structures (propositions, images, or schemes), and then processes (rehearse or elaborate) the symbol structure so that knowledge can be stored in memory and retrieved. The outside world is considered as an input source. Once the sensation is perceived and enters working memory, the critical task is assumed to occur in the individual head. 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 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, 2019).

In comparison, the 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). Scaffolding theory also plays a role in PBLA learning because students are also given complex tasks with gradual assistance to problem-solving (Slavin, 2019). While the 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 critical thinking skills for junior high school students in science learning about temperature and heat. Specifically, the PBLA model has a validity of 3.35 and reliability of 77.10% in improving critical thinking skills for students, which means both are in the medium criteria. PBLA is also effective for increasing the critical thinking skills for students in SMP at a significant level of α=5%, where the average increase in critical thinking skills is at moderate criteria. There is a similarity in increasing the critical thinking skill in two test groups.

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