



Effectiveness of Learning Based Problem Solving with Aspect Ontology, Epistemology, Axiology to Increase Critical Thinking Ability and Understanding Thermochemical Concept of Students

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Abstract

This study is part of a development of problem solving learning model with aspects of ontology, epistemology, and axiology (Model PS-TRILOGI) to improve critical thinking skills and student understanding of Thermochemistry concepts. These objectives can be achieved if the model PS-TRILOGI is valid, practical, and effective. The study design followed the Research and Development. The effectiveness of the model PS-TRILOGI assessed by observers and implemented through the instrument test critical thinking skills and understanding of Thermochemistry concepts at 33 students in Chemistry Education Studies of Tadulako University. The results obtained showed that the percentage of positive responses given by students is very high due sense of excitement, novelty, interest, and support learning media are respectively 94.95%; 90.91%; 90.91% and 96.97%. Indicators that measure critical thinking skills is the interpretation, analysis, inference, and self-regulation. N-gain value for the indicator interpretation, analysis, and self-regulation in middle category of 0.5; while indicators inference at the high category of 0.7. Understanding of the Thermochemistry concept 13 students has a value n-gain of 0.8 to a high category. Based on the results obtained show that the model PS-TRILOGI is effective.

How to Cite

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INTRODUCTION

The chemistry is acquired and developed generally based on experiments involving skills and reasoning for the answer to the question of what, how, and to what natural phenomena associated with the properties of matter, the structure of a substance, a substance changes, laws, principles describe a substance changes, concepts, and theories that explain the change of substance. When viewed from the side of the philosophy of science, the concepts in the sciences (including chemistry) refers to the three questions, namely questions relating to aspects of ontology, epistemology, and axiology. This suggests that the high-level thinking skills including critical thinking skills have an important role to understand the material chemistry (Chandrasegaran, Treagust & Mocerino, 2007).

Critical thinking skills are necessary thinking skills of students in making decisions that are reliable and responsible, investigate problems, asking questions, giving new answers, find information, and draw conclusions (Schafersman, 1991). The results of the study conducted on students of the fifth semester at the University FKIP Tadulako (Afadil, 2013), obtained a general description that the level of critical thinking skills of students for all assessment criteria the highest was 80.8% (a score of 42 out of a maximum score of 52) and the most low 48.1% (a score of 25 out of a maximum score of 52) with the average of the overall sample was 64.6%. This indicates that the level of critical thinking skills of students of Chemical Education FKIP Tadulako against Thermochemical material is still relatively low. Nevertheless, according to Eggen & Kauchak (2012) that the students' critical thinking skills can be improved through learning in the classroom. This is because learning is the result of thinking. Their retention, understanding, and active use of knowledge can be created through the learning experience in which students learn to think about what and how to study it. Further explained that through the application of problem solving steps in the learning of

chemistry with the aspect of epistemology of science can foster students' critical thinking skills (Afadil, 2014).

According to Effendy (2014), the fundamental problem in chemistry learning today are (1) obtaining an understanding of chemical by learners is not intact, and (2) are not optimal development of higher order thinking skills (higher order of thinking skills = HOTS). Learning is not fundamentally produces incomplete understanding and less potential for developing students' higher level thinking skills (HOTS) learners. Further explained that in order to carry out the chemistry learning in accordance with the demands of Curriculum 2013 is required: (1) understanding of chemical materials fundamentally by teachers, (2) the ability of teachers to exploit the subject matter to improve the character and HOTS learners, and (3) the ability of teachers making optimal use of ICT in learning.

The fundamental essence of this learning model developed is a form of chemical problems *penyuguhan* authentic and meaningful to the students to be solved through fundamental assessment cooperatively to help improve critical thinking skills and student understanding of concepts. PS-TRILOGI models is one model of learning which is based on different stages of learning are identification difficulties, problem-solving plan, the implementation plan, communicate, checking back, and evaluation with the aim to improve critical thinking skills and student understanding of chemical concepts. Study concept in which students overcome difficulties to solve the problem referring to the questions relating to aspects of ontology (definitions, theory/law, for example, the existence of, and the similarities/differences), aspects of epistemology (the background, methods/procedures, relations and difficulties), and aspects of axiology (the meaning and benefits).

Characteristics of this model is formulated based on the study of theory and analysis at the preliminary stage and development. PS-TRILOGI models are developed based on the characteristics of a learning model according to

Arends (1997), which gives an overview there are at least four (4) specific characteristics of a learning model, namely: (1) rational logical compiled theoretical designer, (2) the rationale of the learning objectives to be achieved and how learners to achieve these objectives, (3) the activity of teachers and learners are required so the model is applied effectively, and (4) the learning environment needed to achieve the learning objectives. The quality of the resulting model design based on three criteria (Nieveen, 2007). The first is the validity, which include relevance (content validity) and consistency (construct validity). Second is the practicality, the design study model developed can be applied in real field. Third is the effectiveness, namely the implementation of learning model in the field to deliver the result destination.

METHODS

The design used in this research is the design of research and development. The effectiveness of the model PS-TRILOGI is a measure of the quality of the learning model related to the objectives to be achieved in its development, namely improving critical thinking skills and student understanding of concepts. PS-TRILOGI model is said to be effective if it is able to achieve these goals is measured through a sheet of response, critical thinking skills test, and test understanding of Thermochemistry concepts.

Indicators of critical thinking skills are assessed in this study is the interpretation, analysis, inference, and self-regulation. Students' understanding of the concept of Thermochemical include the level of student understanding of Thermochemical concepts tested and apply them to the concrete situation. Ratings critical thinking skills and student understanding of concepts expressed in percentages. Steps of data analysis are as follows: (a) to recapitulate the results of pretest and posttest assessment of each student on the Thermochemistry material, (b) calculate the scores obtained by each student in the critical thinking skills and understanding of

Thermochemical concepts under the rubric of critical thinking skills, (c) calculating the values obtained (N) by dividing the score of each student with a maximum score multiplied by 100.

Determine the categories of critical thinking skills and understanding of the concept of students in each concept by matching the value obtained every student with learning achievement levels are set (an adaptation of Gronlund, 1996) as follows:

$85\% \leq N = \text{Very High}$

$75\% \leq N < 85\% = \text{High}$

$60\% \leq N < 75\% = \text{Medium}$

$40 \leq N < 60 = \text{Low}$

$N < 40 = \text{Very Low}$

Category critical thinking skills and student understanding of concepts expressed either category if the level of every student minimal medium and high. Changes in critical thinking skills and student understanding of concepts Thermochemical determined through calculation of the N-gain (gain normalized) obtained by the students before and after implementation of the model PS-TRILOGI (Hake, 2002).

RESULTS AND DISCUSSION

One of the requirements is to have quality learning model effectiveness or capable of achieving its development objectives. Devices used to assess the effectiveness of the model TPS-TRILOGI is a sheet questionnaire responses, critical thinking skills test instruments and test instruments student understanding of Thermochemical concepts.

Data Questionnaire Student Response to the Implementation Model PS-TRILOGI

Student response questionnaire prepared for the purpose of determining the response or responses of students to learning activities. Aspects of student response assessment consists of four aspects, namely: (a) a sense of happy feeling to the learning component, (b) student opinion on the novelty of learning, (c) student interest in participating in learning activities

with the same model, and (d) student response media support used. The results of the four aspects are:

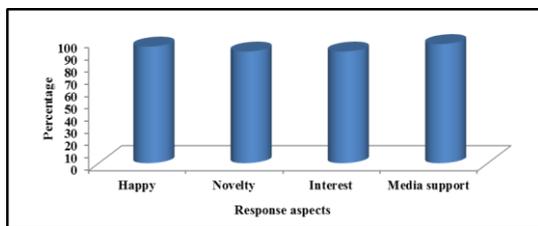


Figure 1. Data Response Students Provide Answers To The Happy feeling, Novelty, Interests, and Media Support of Implementation Model PS-TRILOGI

Based on Figure 1, the students gave a positive response to the expressed sense of fun, new, interest and media support related components and activities implemented in application of the model PS-TRILOGI are at very high category, ie 94.95%; 90.91%; 90.91% and 96.97%. The reason given by students include: (1) Thermochemical materials that were easy to understand, not a lot of complex calculations, given the material studied in depth so as to provide a good understanding, learning material interesting because it is supported by the medium of learning, learning environment, and the way professors teach well, (2) the material contained in LKM is done through learning software, which is varied and profound question is that has never been found while in high school, (3) lesson activities help hone the ability to remember and learn the concepts that have been acquired during high school, increase motivation in learning, and help improve critical thinking skills, (4) the use of media in learning activities to help students improve their understanding of the material Thermochemistry. Utilization of learning software is very interesting in learning activities because it leads to a serious student, focus, and timely in resolving the problem.

Students Data of Critical Thinking Skills

Critical thinking skills that are measured in the subject matter Thermochemical through pretest, posttest, and the results obtained at each learning. The results of the determination of the category of students' critical thinking skills are presented in Table 1.

Table 1. Percentage of Each Student Critical Thinking Skills Indicators After Implementation Model PS-TRILOGI

N	Category	Number of Students				Percentage (%)			
		A	B	C	D	A	B	C	D
1	Very High	0	0	17	0	0.0	0.0	51.	0.0
2	High	0	4	16	3	0.0	12.	48.	9.0
3	Medium	32	29	0	30	96.	87.	0.0	90.
4	Low	1	0	0	0	3.0	0.0	0.0	0.0
5	Very Low	0	0	0	0	0.0	0.0	0.0	0.0
						100	100	100	100
Total		33	33	33	33	.00	.00	.00	.00

Information:

A = interpretation C = inference

B = analysis D=self-regulation

Based on the data in Table 1 it appears that in general increased to the category of medium, high and very high. The increase was achieved through improving the understanding and activities of students answer questions in LKM at every learning demanded reviewing aspects of the concept by answering questions of ontology, epistemology, and axiology. The magnitude of changes in students' critical thinking skills is one indicator of the effectiveness of the model PS-TRILOGI is determined by calculating the N-gain (gain normalized). N-gain calculation value for Thermochemical material presented in Figure 2.

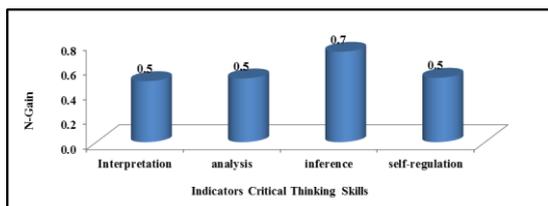


Figure 2. Values of N-Gain Critical Thinking Skills Students on Thermochemistry Materials

Based on Figure 2 shows that the value of N-gain critical thinking skills of students in Thermochemical material is in the range of 0.5 to 0.7. These results suggest that the ability of interpretation, analysis, and self-regulation of students in middle category, inference abilities of students at the high category. That is, the application of the model PS-TRILOGI led to a good increase of the students' ability to interpret, analyze, self-regulation, and led to an increase in very well to the ability of students do inverensi.

Results Test Data Concept Training Student

Understanding the concept of student Thermochemical measured by administering the test before and after the application of learning models. Percentage category Thermochemistry student understanding of the concept after implementation of the model PS-TRILOGI presented in Table 2.

Table 2. Percentage Category Concept Training Thermochemical Students After Implementation Model PS-TRILOGI

Concept	Training Concept Category (%)				
	ST	T	S	R	SR
System	73	9	12	6	0
Heat	79	6	12	0	3
Changes in enthalpy	75	15	5	4	1
Thermochemistry Reaction	76	15	7	2	0
Work	73	15	9	3	0
Energy Changes Within Combustion	76	15	5	5	0
enthalpy changes	80	14	5	2	0

Concept	Training Concept Category (%)				
	ST	T	S	R	SR
Changes in enthalpy of neutralization	73	15	9	3	0
Calorimeter Diagram	78	13	6	2	1
enthalpy changes	64	21	15	0	0
Hess Law	62	21	14	2	2
The formation enthalpy change Standard Energy Association	76	8	12	2	3
Average	84	5	4	4	3

Based on data from Table 2 shows that, in general category student understanding of concepts in materials Thermochemical increased after implementation of the model PS-TRILOGI. Analysis of changes in student understanding of concepts Thermochemical can be determined by calculating the N-gain (gain normalized) obtained by the students before and after implementation of the model. The result of the calculation of the value of n-gain every concept is presented in Figure 3.

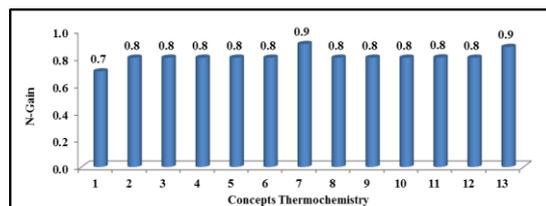


Figure 3 shows that the general understanding of the concept of student Thermochemical increased after application of learning models. This is evidenced from the 13 concepts tested obtaining the average value of the N-gain in the high category. That is, the application of the model PS-TRILOGI led to excellent improvement of the understanding of the students Thermochemical concept.

Discussion

One of the requirements of quality learning model is as effective or capable of achieving its development objectives (Nieveen, 2007). According to Jakobsen, Eggen, & Kauchak (2009) that effective learning can occur when learners are actively involved in organizing and finding relationships through the provision of information provided feedback. The results of these activities not only enhance the students understanding of the learning material but also involves thinking skills.

Students Response

Response was defined as a form of readiness in determining a positive or negative attitude towards the object or situation that is shown through the perception and participation (Gie, 1998). Student response with arguments against the components and learning activities written in the questionnaire. The results obtained on the implementation of the study showed that in general the students give positive response to the application of the model PS-TRILOGi in Thermochemistry learning.

Positive responses given by students of the components and the learning activity indicates that students have a high interest in learning. According to Gie (1998) that facilitate the achievement of the concentration of interest in one's mind and concentration on an object. Interest causes someone did attempt to approach, know, own, control, or associated with the object. Good feelings shown by students towards learning component is inseparable from the lecturer's ability to motivate students by building a fun learning environment. his is in accordance opinions Arends (2008), which explains that the attributes associated with motivation emphasized the importance of building a learning environment that is fun, harmless and safe, which at a certain level learners have self-determination and responsibility for their own learning. Attitude and orientation of teachers in certain learning situations have a considerable influence on the response of students to a variety of learning situations.

he responses given by the students depending on student interest in learning to follow. Comments given by students associated with interest following the lecture by using the model PS-TRILOGi shows serious attention to learn something new. According to Syah (1999) there are two factors that affect the interest of learners following study, namely: (1) The intrinsic factor; things and circumstances that come from within his own self-learners who can push action learning, please include the feeling of the material and the need for such material, (2) extrinsic factors; things and circumstances that come from outside the individual learners are also encouraged her to do learning activities, includes praise, reward, learning environment, and how to teach.

The positive response given by the students associated with the support of the media in helping students perform a concept study with aspects of ontology, epistemology, and axiology and improve critical thinking skills in accordance with the indicators specified in resolving the problem. This is illustrated by the results shown by the students through activities during the learning process. Activities undertaken by the student is not in spite of the high interest, passion and motivation in learning. Student Activities LKM working in earnest show their intrinsic motivation. Intrinsic motivation is the behavior exhibited by a person driven internally by interest and curiosity alone or for pleasure gained from an experience (Arends, 2008).

The Critical Thinking Skills of Students

Critical thinking skills is an ability that is not innate (Schafersman, 1991). Critical thinking skills, including the ability to be taught so that these skills can be learned (Halpern, 1999; Garratt, Overton, Tomlinson, and Clow, 2000; Robbins, 2005). Based on the above opinion, the learners should be given meaningful experiences for learning in order to me-ngembangkan critical thinking skills. That is, teachers are obliged to condition pembelajar-an so that learners are able to develop intelligence and critical thinking skills. Indicators of critical

thinking skills achieved in this research is the ability of students interpretation, analysis, inference, and self-regulation.

Interpretation of the result of thinking is based on a particular view as a starting point (Facione, 2013). The results obtained by the student in accordance with the description given by Fisher (2009), which explains that critical thinking requires the ability of interpretation and evaluation of observation, communication, and sources of other information, but it also requires skills in thinking of assumptions, in the filed relevant questions, and in drawing implications.

According Facione (2013), the analysis is the ability to identify relationships things are expected with tangible evidence, eg statements, questions, concepts, description, evidence, experience, information, and opinions. Ability gained students in accordance with the opinion expressed by Kheng (2008) that analyzes as one indicator of the ability of critical thinking is the ability to determine the parts making up a statement, question, concepts, description or other purposes to disclose the information and make a further explanation in deciding and implementing appropriate actions destination. Therefore, it can be concluded that the activities of student conduct studies with aspects of the concept of ontology, epistemology, and axiology on the application of the model PS-TRILOGI is able to enhance the critical thinking skills of students especially analytical skills in problem solving.

According Facione (2013), the inference is a process to interpret and summarize information in order to achieve the goal. The ability demonstrated by the student in accordance with the opinion expressed by Kheng (2008) that the inference is the ability to identify and ensure the elements required to describe the reasons in making inferences, forming predictions and / or hypotheses, adjust tactics and strategy taking into account the information in the form of data, statement, principles and concepts. herefore, it can be concluded that the activities of the students review the concepts with aspects of ontology, epistemology, and axiology on the application of

the model PS-TRILOGI able to foster critical thinking skills of students, especially the ability of inference in resolving the problem.

Self-regulation is the awareness that is owned in the control of a person's cognitive activities, which resulted in deductions, particularly in applying the skills to analyze for consideration by way of questioning, to make sure, validate or correct the reasoning of others (Facione, 2013). The results obtained by the student in accordance with the explanation put forward by Kheng (2008) that self-regulation is defined as the ability to identify and analyze for consideration by way of questioning, to make sure, validate or correct the reasoning of others. Based on the above it can be concluded that the activities of student conduct studies with aspects of the concept of ontology, epistemology, and axiology on the application of the model PS-trilogy slowly able to foster critical thinking skills of students, especially the ability of self-regulation to solve the problem.

Thermochemistry Concept Training of Students

Comprehension involves many processes that requires thinking, as explained, finding evidence, justifying thoughts, give additional examples, generalization, and connecting the parts to the whole (Brasford in Jacobsen, Eggen, & Kauchak 2009). The ability of understanding of the concept in this study was measured through students' ability to use the concepts, principles, theories, and laws Thermochemistry in solving the problem indicated by the test scores of students understanding of the Thermochemistry concept.

Students are encouraged to understand the basic applications Thermochemical materials in everyday life, requires students to have the skills of analysis, and measure the energy generated by the reaction as heat by the condition (Atkins, 1999). This is consistent with the explanation put forward by Gagne that the ability to distinguish a prerequisite for studying the concept. The concept may contain information which is significant in related or have a relationship with another concept

(Ibrahim, 2012). That is, every concept does not stand alone, but related to other concepts, so as to be able to learn the concept of each person must be able to distinguish one concept to another concept. Based on these images, to help improve understanding of the concepts used in the study material Thermochemical model of PS-TRILOGI

In general, the percentage of students' understanding of concepts Thermochemical increased, these conditions occur due to several factors, among others: (1) Activity student conduct studies concepts with aspects of ontology, epistemology, and axiology described in LKM is helping students improve understanding of concepts to solve problems associated with Thermochemistry, (2) A concept that examined aspects of ontology, epistemology, and axiology to solve a problem largely repeated in solving other problems in each lesson, (3) concept study with aspects of ontology, epistemology, and axiology in solving problems related to material Thermochemical always learning continuously from one to the other learning.

CONCLUTIONS

Based on the results and discussion of the response data, critical thinking skills, and understanding of the students Thermochemical concept at all study showed that the implementation of the model PS-TRILOGI in learning can improve understanding of the Thermochemistry concept of critical thinking skills. Therefore, it can be concluded that the model PS-TRILOGI is effective.

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