

The Effect of Buffer Chemistry Learning Strategies Based on Investigation to Critical Thinking Skills, Metacognition, and Mastery of Concepts of Senior High School Students

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Abstract—The study objectives are 1) to explain the effect of learning strategies based on investigation to critical thinking skills, metacognition, and mastery of the concepts at senior high school students; 2) to empower critical thinking skills and metacognition at senior high school students; and 3) to compare the level of the concept mastery of buffer solution chemistry between students who are taught based on the investigation learning and conventional learning. The methods used are preliminary observation, preparation of learning tools, development and verification of learning tools, trial and dissemination, pre-non-test, and implementing of chemistry learning tools based on investigation learning for senior high schools. The subjects of this study were senior high school students in Makassar city and Maros district. Learning tools are used in this study are Planning of Learning Implementation on Investigation Worksheets, a book of the investigation model, and the non-test also test Instruments for the Chemistry subjects of eleven grade of Senior High School. The research used was the pretest-posttest control group design. The results showed that firstly, there is an effect of the chemistry learning strategies based on the investigation to critical thinking skills, metacognition, and the concept mastery of senior high school students. Secondary the critical thinking skills and metacognition of senior high school students are empowered which is characterized by increasing critical thinking skills and metacognition of students after the learning process, and thirdly the level of the concept mastery of buffer solution chemistry of students who are taught by investigation learning is higher than conventional learning.

Keywords—chemistry learning, concept mastery, critical thinking, investigation, metacognition

I. INTRODUCTION

The current phenomenon in the learning process in secondary schools is that teachers do not facilitate and encourage students in obtaining information or knowledge by empowering analytical and critical thinking skills. Students are more directed to learning or to receiving information through simple thinking activities and also through a process of listening to teacher's explanations in the classroom and through the completion of home tasks by memorization learning techniques. It can be seen from the learning process that has been carried out by the teacher in general and student learning methods in general. [1] has found that chemistry teachers of a senior high school have

not implemented an appropriate learning process in facilitating students in developing their critical thinking skills. Students are less actively involved in learning and finding information themselves. Students were not facilitated in processing information and constructing it in the minds of students. The class and homework assignments have not improve ability students to analyze, synthesize, and evaluate the data or problems, but rather involve activities at the level of simple thinking, for example through question items to write the definition of acid-base, write the characteristics of the acid-compound and the base-compound, and group the following compounds into acid and base compounds. Also, the role of the teacher is still more dominant as a transfer of information or knowledge to students as well as a source of information.

Furthermore, [2] found that there is lacking metacognition. Students are more given information and problems that require learners to memorize well without actively involving learners in finding knowledge. The learning method applied by the teacher is also still dominated by the lecture method which forces students to become passive learners. Meanwhile, [3] stated that the level of the concept mastery of buffer solution chemistry for students at MAN Dampang Bantaeng district is low, that is, there are 75.86% of students who had not reached the completeness criteria of at least 70.

Therefore, an appropriate learning strategy is needed and able to overcome these problems. One of them is learning based on an investigation. This learning emphasizes on aspects of the investigation activities on the topic of the problem with the freedom to determine the way and freedom in choosing learning resources in finding an explanation of the problem. The study topic is also contextual or a real in life. For example, lemon juice was added to the milk; then milk will clot. The chemical question is why it can happen. Of course, to answer this question, the student needs to perform an investigation by conducting the first experiment to prove this statement.

Furthermore, students conduct literature searches to obtain explanations of this phenomenon. Many happen in real life if this learning experience continues to train for students, then one day the potential for critical thinking skills and skills in processing knowledge (metacognition) will

grow and develop well. In other statements that the potential for critical thinking and metacognition skills will be empowered well, which is marked by changes in cognitive levels, such as the level of mastery of concepts.

II. METHODOLOGY

This research type is a quasi-experiment by comparing two learning strategies between learning based on the investigation (in this study used a discovery learning model) and traditional learning. The methods used are 1) initial observation, 2) preparation learning tools, 3) development and verification of learning, 4) testing and dissemination devices, pre-non-test, and 5) implementing of chemistry learning tools based on investigation learning for senior high schools. The subject of this study was the students of SMAS Makassar Raya of Makassar city and SMAN 8 Maros district. The learning tools used are Planning of Learning Implementation based on the investigation, Investigation Worksheets, a book of the investigation model, and the non-test and test Instruments for the Chemistry subjects of eleven grade of Senior High School. The research design used a quasi-experiment, namely pretest-posttest control group design.

The instrument used in this study is cognitive test items to measure mastery of the concepts of Chemistry [4]–[6], critical thinking sheets [7]–[9], and metacognition awareness questionnaires MAI [10]. The criteria for testing the effect of learning variables on critical thinking skills, metacognition, and mastery of concepts of students on the buffer solution subject used t-test.

III. RESULTS AND DISCUSSIONS

A. Research Result

1) *Validity, practicality, and effectiveness of learning chemistry tool based on an investigation using discovery learning models.*

The chemistry learning strategy developed has a validity level of 3.40 from a maximum score of 4, with a valid category. The level of practicality is 1.70 from a maximum score of 2, with a practical category. The level of effectiveness based on mastery of chemical concepts, obtained 86.72 of KKM 70, with a high category. For the level of critical thinking skills including the medium category, 93.10% of students have critical thinking skills. And for students' metacognition abilities obtained at 83.25%, meaning that students have metacognition in the category began to develop. Table 1 shows that each school provides a post-test score through higher investigative / discovery learning than conventional learning for each variable.

TABLE I. DESCRIPTION OF POST-TEST RESULTS

Variable	SMAS Makassar Raya		SMAN 8	
	Discovery Learning	Conventional learning	Discovery Learning	Conventional learning
Critical Thinking Skills	92.170	82.770	96.330	89.320
Metacognition	219.080	211.223	198.150	196.270
Mastery of Concepts	62.220	42.430	80.240	73.780

2) *The influence of learning models based on the investigation and conventional learning on critical thinking skills, metacognition, and mastery of the chemical concepts of students.*

Based on the results of the t-test, each school showed that 1) there was an influence of investigation learning model to critical thinking skills of students, 2) there was an influence of investigation learning model to metacognition awareness of students, and 3) there was an influence investigation learning model to the mastery of the concept of buffer solution chemical of students.

3) *Empowering critical thinking skills and metacognition of students*

The study result showed that critical thinking skills and metacognition of student are empowered through investigation learning, both at SMAS Makassar Raya and at SMAN 8. For aspects of critical thinking skills are characterized by an average post-test score, respectively, 92.17 and 91.64 from a maximum score of 125 with the medium category for students at SMAS Makassar Raya and SMAN 8. Meanwhile, for the metacognitive awareness with the average post-test score is 219.08 and 197.14 of the maximum score of 260 with the developing category for students of SMAS Makassar Raya and SMAN 8.

4) *Mastery of chemical concepts for buffer solution subject.*

The results showed that the level of mastery of the chemical concept for buffer solution subject was 62.22 with the high category for students at SMAS Makassar Raya and 80.22 with very high categories for students at SMAN 8.

B. Discussions

The level of validity of this tool is obtained from the results of validation by education and learning experts. Some aspects that can give the level of validity of this device are the structure and organization of the implementation plan of learning, assessment clearly, and operational starting from the formulation of the competency to the evaluation/assessment formulation. Book model is compiled using the standard book format. The book contains clarity of instruction on the use of model books, the subject of division, a clear numbering system, the suitability of text content on the topic of investigation, the presentation of texts accompanied by contextual chemistry cases, arrangement of informative space / layout of text and tables, using words that comply with the rules Indonesia language. Besides, the sentence structure on the content used must be easy to understand (subject to the investigative learning model), and communicative. Furthermore, the student activity sheet is presented in an investigation learning format that covers the topic of investigation and is equipped with instructions on how to conduct an investigation and a place where information sources can be obtained related to the subject of the investigation, as well as the form of the results of the survey. Besides, the validity of this tool is also determined by the availability of test and non-test instruments in which test items and questionnaire items are presented based on indicators of achievement of competencies by using language that is easy to understand and unambiguous or does not lead to multiple interpretations.

Some of the results of previous studies that are relevant to the validity of research on the development of investigative learning tools using discovery learning and inquiry for buffer solution subject includes research conducted by [2] and [11].

It is learning investigation using discovery learning influences critical thinking skills, that caused by stages in learning that can empower aspects that are including in critical thinking skills. An example is the phase of stimulation and identification of problems (problem statements) in discovery learning. This phase can train critical thinking skills of the student in exploring study materials or investigations and present problems (can be questioned) and skills in raising critical and contextual questions, including of the stage of data collection and processing. This phase can empower critical thinking skills in considering information sources and observations.

The skills of students in analyzing data and literary skills can also be empowered in this learning phase. For example, in the investigation process, it was found that there was a substance or solution is buffer or not. This, of course, hopes students to find for explanations including defining terms included in the scope of buffer solutions, for example, the term weak acid with its salt. This thinking skill can also be trained through various interactions with learning resources including between students and interaction with the teacher. The next phase is verification and generalization. This phase can empower critical thinking skills of students in identifying information that has been analyzed including identifying assumptions that have been stated. Other critical thinking skills that can be trained in this phase are thinking skills in deducing and inducing concepts of buffer solutions.

The investigation using discovery learning affects metacognition, this is because the stages in learning can empower aspects that are covered in metacognition. For example the phase of stimulation and identification of problems (problem statements) in discovery learning. This phase can train metacognition awareness of students in performing systematic planning actions and practice skills in generating cognitive questions in themselves about what has been understood and what will have to be understood or which parts should be learned from the chemical subject of buffer solution. Similarly, the data collection and processing phase. This phase can empower students in managing their learning methods, how to study these chemical materials. In this phase, students can also think of the possibilities of learning strategies that can be applied especially in parts of the material that are classified as complex to be able to understand correctly, for example how to learn about the determination of the pH of a buffer solution. The next phase is verification and generalization. This phase can empower metacognition awareness of student in monitoring their cognition; what material concepts have been understood and what concepts have not been understood from the results of the collection and processing of information or knowledge they have done. This phase also trains students in evaluating their cognitive level through the provision of exercise tests and or self-assessment. This can foster awareness of students about their level of mastery of the material that has been learned.

Some studies that are relevant to this finding include the results of research obtained by [12] who found that there was an influence of the learning model on the knowledge

and metacognition awareness of students in High School at Polewali, West Sulawesi. In addition, the results of research from [13], found that the discovery strategy influence students' metacognition skills and conceptual understanding. [1] also found the investigation learning using problem-based learning) affects metacognitive awareness of students.

Empowering critical thinking and metacognition skills of students can affect the mastery of the chemical concept of buffer solutions. Critical thinking skill is one of the high-level thinking skills that can be used in the formation of the conceptual system of students. Critical thinking is reasoning and reflective thinking by emphasizing decision making about what must be believed and done [9]. Students who have high critical thinking skills will have an impact on the level of mastery of concepts. [14] reports that students who have good critical thinking skills have a good understanding of the mathematics concept.

Various literature on conceptual change in chemistry provides many benefits to students about the ideas of science or knowledge. According to Bodner (1991) in [2] that research of understanding of student on the idea of science after conventional learning shows a productive change in student conceptions is very lacking. In addition, although conventional learning (didactic-teaching) has proven to be quite successful in conveying facts, rules, procedures, and algorithms but it is not effective in helping students to improve and build their ideas about the concept of science, because the learning method does not need and does not encourage achievement metacognition of students [2]. Students may get answers is correctly, but the opportunities and guidance given to understand and develop scientific ideas are expected to be very limited. [15] found that in addition to understanding content, there are several other important components that play a role in solving problems. Problem-solving can also be influenced by the use of heuristic problem solving, monitoring and control (metacognition), trust and influence, and practical communities (groups of people involved cooperatively). Although [4] provides some illustrations of the problem-solving methods used, there are two opposing interpretations. The first is "traditional" defined where problem-solving is "doing the tasks that have been set before you"; it is this usage that brings out a boring vision in the practice of questions. The "contrast" (second) definition of the problem posed by [15] is "learning to deal with new and foreign tasks when the relevant solution method is unknown (only some are in control). Problem-solving in the second definition is an important metacognitive activity. Besides, [16] and [1] also stated that investigative learning affects the understanding and mastery of chemical concepts.

IV. CONCLUSIONS

The stages of the process of developing chemical learning tools refer to the 4-D pattern by Thiagarajan include defining, designing, developing, and disseminating learning tools. The results obtained learning tools in the form of Planning of Learning Implementation based on an investigation, Investigation Worksheets, a book of the investigation model are valid, and also the test and non-test instruments are effective and practical. The study showed that there is an effect of the chemistry learning strategies based on an investigation to critical thinking skills, metacognition, and the concept mastery of senior high

school students of the buffer solution subject. The other result is critical thinking skills, and metacognition of senior high school students are empowered with characterized by an increase in critical thinking skills and metacognition of students after the learning process. The use of learning tools based on an investigation at the broad level of implementation through comparative tests or influence tests can develop critical thinking skills, metacognition, and the concept mastery of student about the concept of chemical buffer solution higher than conventional learning.

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