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## The effectiveness of module with critical thinking approach on hydrolysis and buffer materials in chemistry learning

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**Abstract.** The research aims is to find out the effectiveness of critical thinking approach in Chemistry learning especially on hydrolysis and buffer materials. The level of its effectiveness was viewed from the students' learning outcomes including knowledge, attitude and skill domains. The data were collected through validation sheets, questionnaires and tests, which were then analyzed by using descriptive quantitative method. The first step conducted was validating the module that was going to be used in the learning processes. The students' learning outcome on knowledge domain was very good, viewed from the classical attainment by 88.63% with N-gain 0.718 with high criteria. It was also viewed from the students' criticality level in solving the given problems. The result of the study revealed that more than 75% of the students obtained critical and very critical criteria in solving the given problems. The students' attitudes and skills values were viewed through observation sheets during the learning processes. The result of the observation stated that more than 75% of the students showed good and very good attitudes and skills values. Based on the data, it could be concluded that the module with critical thinking approach was effective to be used on hydrolysis and buffer materials.

### 1. Introduction

The act number 3 year 2003 regarding national education system in Indonesia stated that education means conscious and well-planned effort in creating a learning environment and learning processes so that the learners would be able to develop their full potential for acquiring spiritual and religious strengths, develop self-control, personality, intelligence, morals, and noble character and skills that are needed for him/ herself, for the community, for the nation, and for the State. Learning activities are conducted in order to achieve good learning outcomes. Not only from students' knowledge, but also from their attitudes and skills the learning outcomes are viewed [1].

Chemistry is one of the most important branches of science as it allows the learners to find out what was exactly going on around them [2]. It has to be taught in Senior High Schools for explaining some phenomena in life and since it is essential to develop their generic skills such as critical thinking, interest and curiosity [3]. On the other hand, chemistry is considered as one of bewildering subjects since it consists of microscopic, macroscopic and symbolic parts [4]. This kind of reasoning is what helped the students to understand the Chemistry materials more easily.

According to a study, it was stated that chemistry was one of the subjects with a low-level critical thinking [5]. This is in line with the problem faced by the students especially the students at Kejobong Senior High School. The students' poor comprehension affects on the low of learning materials deepening, thus the students would face some difficulties in solving certain chemistry problems which require gradual completion.



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One attempt which can be conducted to deal with this students' difficulty is by applying one approach which are supposed to direct the students to think gradually. Critical thinking is effective to be applied especially on some contents or subject matters whose gradual discussion [6]. The application of gradual critical thinking, presentation of real problems in life, and giving some feedbacks are effective to be applied in science classes [7]. Critical thinking is one's thinking style in considering the implications, responses, results and projects outcomes [8].

Hydrolysis and buffer are considered as bewildering chemistry subjects by most of the students in XI grade. Salt hydrolysis is one of the final materials given with a material concept which the students are having some difficulties in understanding and mastering it [9]. The students' inability in differentiating the concept of hydrolysis and buffer and the students' ignorance of the origin of the hydrolysis and buffer formula leads them to have those difficulties. As the result, when they face the related questions, they have difficulty in analyzing them.

Besides using an appropriate approach, another attempt which can be conducted in dealing with the students' problems is by adjusting learning materials to suit the needs of the students. Learning some bewildering chemistry materials can be solved by developing its worksheets or modules [10]. Module is one type of learning materials that contained materials and worksheets to lead the students to think critically in analyzing and solving them.

## 2. Methods

The methodology in this study was Research and Development. It was a module focused on hydrolysis and buffer materials using critical thinking approach. The research was conducted at Kejobong Senior High School, Purbalingga Regency on March 21 until April 18 2016. Research instruments used in this study were sets of learning media including sections of syllabus, lesson plans, module, evaluation tools (knowledge, attitudes and skills domains) and validation sheets of learning media.

The first step was *defining*; it included collecting information obtained by conducting observation and interview with chemistry teachers at Kejobong Senior High School. An analysis of the curriculum, materials and students were found as the result of this step. The result of the analysis then became the basis of the module development in this study.

The next step was *designing*. In this step, composing learning tools were done by intensively consulting with some advisors. After the learning tools were obtained as draft 1, some assessments were conducted by some experts; in this case they were a chemistry lecturer at UNNES, Dr.NanikWijayati, M.Si and two chemistry teachers at Kejobong Senior High School, DwiWasiati, S.Pd. and YuliAstuti, S.Pd. The assessment result of the three experts then was used as a material for improving the module before it was used in learning processes.

The third step was *developing*. It was an improvement of the design which had been tested on a small scale and had to be retested on the large one. The data of the large-scale trial was used to find out the developed module's feasibility, legibility and practicality. The small scale trial involved ten students in grade XII IPA 1 representing low, medium and high ability according to the recommendation from their chemistry teachers. The result of this small-scale trial was then revised and tested on the large scale in grade XI IPA 3 involving 21 students.

The final step was implementation; the module was used in the chemistry learning processes to measure its effectiveness and to find out students' responses after using the module. The module implementation was conducted in grade XI IPA 1 and XI IPA 2 involving 44 students.

The data obtained were to be analyzed to find out the level of the instruments' validity and reliability. Essay questions used were tested by using content validity, and  $\alpha$ -Cronbach was used to test its reliability. The questionnaires of the students' responses were used to find out the module's legibility and practicality; and experts' validation sheets were used to find out the module's validity in terms of its content, presentation, language and graphic, which the reliability was tested by using  $\alpha$ -Cronbach. Learning instruments were considered reliable if  $r_{11} \geq 0.7$  [11]. The module's effectiveness was viewed from the attainment of the students learning outcomes and was then tested by using N-gain in order to find out the improvement of the outcomes after using the module.

### 3. Results and discussion

The development in this research referred to 4-D model which consisted of defining, designing, developing, and disseminating [12]. However, this research only reached the developing stage. In the defining stage, the data collected were in the forms of curriculum analysis, material analysis, and student analysis. All of the result analyses were used as considerations in determining a suitable strategy as the basis of the module development in this research. The most suitable strategy based on the three analyses was a module development focused on deepening the hydrolysis and buffer materials with critical thinking approach.

In the designing stage, the module was started to be composed. The developed module composition consisted of a cover, a preface, a table of contents, core competences, basic competences, module characteristics, materials, evaluation questions, answer keys, summaries, references, appendices, glossaries, and the writer's biography. The module was then validated by three experts regarding the aspect of its content, presentation, language, and chart. The assessments of the experts revealed that the critical thinking-based module was very feasible to be used in the Chemistry learning processes.

In the developing stage, small-scale and large-scale tryouts were conducted. The small-scale tryout involved 10 students of grade XII IPA 1 of Kejobong Senior High School. The tryout was done in order to ask for the students' opinions regarding the developed module. In this stage, the obtained results were the students' positive responses. The large-scale tryout was held in grade XI IPA 3 involving 21 students. This tryout was done in order to find out the module readability before it was implemented in the Chemistry learning processes. The chosen classes for the implementation stage were grade XI IPA 1 and XI IPA 2 involving 44 students. In the implementation stage, the data of the results of the students' learning outcomes, attitudes, skills, and responses on the satisfaction during the learning processes using the module were obtained to find out the module effectiveness [13]. The results of students' learning outcomes on the implementation scale were presented in Table 1 below.

**Table 1.** The Students' Learning Outcomes on the Implementation Scale

Information	Class XI IPA 1		Class XI IPA 2	
	<i>Pretest</i>	<i>Posttest</i>	<i>Pretest</i>	<i>Posttest</i>
The Average Score	16.86	77.77	16.86	75.45
The Minimum Score	9.50	57.50	5.50	59.00
The Maximum Score	38.00	94.50	26.50	81.50
The Number of the passed students	0.0	20.0	0.0	19.0
The Number of the failed students	22.0	2.0	22.0	3.0
Classical Attainment	0%	90.91%	0%	86.36%
The Average of the Classical Attainment		88.63%		
<i>N-gain</i>	0.732		0.705	
The Average <i>N-gain</i>	0.718			

Overall, the attainment of the students' learning outcomes from the pretest and posttest analyses increased significantly by 0.718 with 0.732 for grade XI IPA 1 and 0.705 for grade XI IPA 2. In the pretest result of 44 students, no one got grades above the Minimum Attainment Learning Standard nor met the attainment criteria, either in XI IPA 1 or XI IPA 2. Afterwards, the students participated in the learning process using the module focused on the deepening of hydrolysis and buffer materials with critical thinking approach and were given posttest at the end of the lessons. The posttest results showed that there were 2 students of grade XI IPA 1 and 3 students of grade XI IPA 2 who did not meet the attainment standard score (or less than 75). The classical attainment average of those classes was 88.63%. The students' learning outcomes which also became a reference were the learning outcomes of a control class that was a class without hydrolysis and buffer modules in the learning process. The learning outcomes of the students in the control class were presented in the Table 2.

**Table 2.** The Learning Outcomes of the Control Class Students

Information	Activity	
	Pretest	Posttest
The Average Score	22.200	39.175
The Minimum Score	10.500	26.500
The Maximum Score	38.000	77.000
The Number of the passed students	0.0	2.0
The Number of the failed students	20.0	18.0
Classical Attainment	0.0%	10.0%
<i>N-gain</i>	0.22	

The results showed that there was an increase in the students' scores for pretest and posttest although the increase obtained by the control class was not so significant that was only 0.22 with 10% attainment. This showed that there was a difference in the learning outcomes between the class with critical thinking skills and the control class. This result was supported by a previous research that there was a significant difference in the learning outcomes between the class with critical thinking skill and the class without it, but that was not influenced by the students' gender [14].

The students' criticality level or their critical thinking outcomes during the learning processes using the hydrolysis and buffer modules with critical thinking approach was scored using evaluation questions which in their complete used the critical thinking stage. The recapitulation of the students' critical thinking outcomes could be seen in Table 3.

**Table 3.** The Recapitulation of the Students Critical Thinking Outcomes

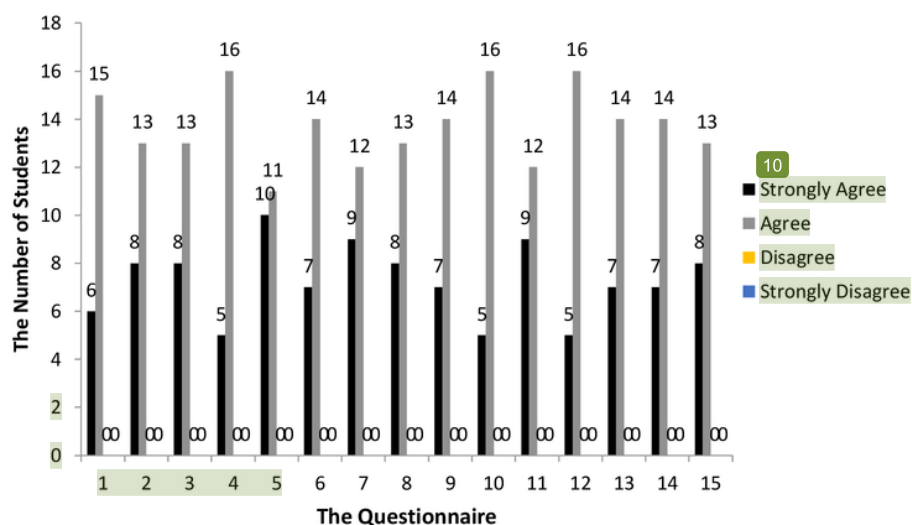
Score Interval	Criteria	The Number of the Students
$76 \leq \text{score} \leq 100$	Very Critical	33
$51 \leq \text{score} \leq 75$	Critical	11
$26 \leq \text{score} \leq 50$	Uncritical	0
$0 \leq \text{score} \leq 25$	Very Uncritical	0

That result stated that 33 out of 44 students were categorized as *very critical* in solving the given questions of evaluation. The other eleven students were also categorized as *critical* in solving the existing questions. The classical attainment scored more than 75%. The students' activities in the classroom were observed through the attitude observation sheet and skill observation sheet whose reliability had been analyzed. The validation of the observation sheets were done by the Chemistry lecturer and teachers in Kejobong Senior High School. The reliability of the observation sheet of discipline and responsibility and the skill observation sheet of the students was respectively presented as follows (1) 0.87, (2) 0.73, and (3) 0.83, thus it could be claimed that all three observation sheets used were reliable. The students' skill was observed and scored when they did the presentations at the end of the learning process before the posttest. Based on the observation data of the students' skill, most of the students of XI IPA 1 and XI IPA 2 were categorized as *good* in the presentation. However, if it was viewed from the attainment scores of each indicator, not all indicators were more than or equal with 75%. The attainment of the skill assessment for each indicator was presented in Table 4.

**Table 4.** The Attainment Assessment for each Indicator

Assessment Indicators	Attainment (%)
1	75.57
2	53.58
3	55.34
4	75.00

The result of the students' responses toward the module used during the learning processes was measured through the students' questionnaires with the reliability 0.75. The students' questionnaires had scale from 1 to 4 and consisted of 15 item aspects. The recapitulation of the students' responses towards the module on every item was presented in Figure 1.



**Figure 1.** The Recapitulation of the Students' Responses towards the Module on Every Item

Note: (1) the writing readability, (2) image clarity, (3) caption, (4) the image attractiveness, (5) the suitability of the image with the material, (6) the basic concept conformity, (7) evaluation question, (8) the material coherence, (9) symbol clarity, (10) the exercise suitability with the material, (11) learning material ease, (12) learning motivation, (13) module attractiveness, (14) the ease for self study, and (15) the critical thinking stage made it easier for the students to solve the problems

Based on the students' questionnaire responses, showed that the students' responses towards the module used during the learning process were generally good. Most of the students stated that they agreed and very agreed with the questionnaire items given.

#### 4. Conclusion

The research results showed that (1) the module which focused on deepening hydrolysis and buffer materials using critical thinking approach was considered to be valid, (2) the module which focused on deepening hydrolysis and buffer materials using critical thinking approach was proven to be effective in improving the students' learning outcomes on the knowledge, attitude, and skill aspects, and (3) the module which focused on deepening hydrolysis and buffer materials using critical thinking approach got good responses from the students.

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