Conference Paper

Analysis Of Students' Conceptual Understanding Assisted By Multirepresentation Teaching Materials in the Enrichment Program

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Abstract

This purpose of this research was to determine the students' conceptual understanding assisted by acid-base multi-representation teaching materials in the enrichment program. The type of research was case study that used combination of qualitative and quantitative methods by involving 49 second grade science students of State High School in Kudus who have passed/completed acid-base material. The sampling technique was carried out by purposive sampling. Conceptual understanding was analyzed using reasoned questions, namely three tier multiple choice test as pretest and posttest. The results showed that students' conceptual understanding of acid-base material was considered as high category. Achievement of students' conceptual understanding has increased, as seen from the results of students' pretest and posttest namely from 37% to 71%. Overall, enrichment learning assisted by multi-representation teaching materials is effective when used in learning so that the achievement of students' conceptual understanding of acid and base material is categorized as high category.

Keywords: teaching material; multi representation; conceptual understanding; enrichment program.

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1. Introduction

Curriculum is defined as a set of settings regarding the purpose of content and learning materials as well as ways used as guidelines for the implementation of learning activities to achieve certain educational goals (Hamalik, 2011). The learning process of the 2013 curriculum is more directed at scientific learning which includes asking, observing, gathering information, associating, and communicating. The K-13 learning activities compiled in the learning implementation plan are divided into three points, namely preliminary activities wherein the activity starts with the teacher opening the learning process, providing motivation to students, then the core activities of student-centered learning and the teacher as mentors during learning. Finally, the closing activity where in this activity, the teacher provides conclusions involving students and closes the learning process (Mardiana and Sumiyatun, 2017).

Chemistry studies the material from the structure, properties, changes and energy that accompany these changes. Chemical material uses very different chemical terms and languages, as well as a number of abstract concepts (Chang, 2003). Chemistry has characteristics that are not possessed by other branches of science, namely concepts in chemistry involve aspects of study both macroscopic aspects (observable properties), microscopic (substance-forming particles) and symbolic (substance identity symbols) (Rusminiati, *et al.,* 2015). These three levels of representation require students to think further about the chemistry so that deep thought can sometimes cause confusion and different understanding in describing the nature, scope and concept of chemistry (Talanquer, 2011). One of the high school chemistry materials is acid-base material that requires a macroscopic, microscopic, and symbolic explanation so that students are able to absorb the material delivered thoroughly.

Conceptual understanding is the ability of a person to be able to explain, differentiate, give examples and connect a concept of what he knows with new knowledge (Dali, 2014). Understanding concepts in chemistry is from abstract to being understood by students. Student's conceptual understanding is influenced by various factors, namely internal and external factors. Internal factors can come from the students themselves, while external factors come from outside such as teaching methods, use of learning media, and teaching materials used. Conceptual understanding is one aspect that needs to be considered in the teaching and learning process because understanding concepts will affect student learning outcomes. Students' learning outcomes are reflected as students' ability to master the material that has been taught (Sastrika *et al.*, 2013).

The results of observations obtained from one of the State High Schools in Kudus showed that there was no enrichment program for students yet who have been completed the material. The average percentage of students who completed per class on acid-base material in the school is 40 to 60%, so further action was needed by providing enrichment programs. Enrichment is an activity carried out by the teacher to students who have good time and learning outcomes than their friends (Irham & Novan, 2013). The enrichment program wass expected to enable students to understand the concept material in their entirety and to know more broadly related to chemical material especially acid base in daily life.

The learning process required the right media to support students' understanding of the material taught in class. Teaching material was one of the learning media that able to assist students in understanding lessons and could overcome the limitations or constraints of time during enrichment learning. This has caused the enrichment program in schools to not be implemented optimally. Less optimal enrichment programs in schools because the time was focused on remedial programs for students who have not yet reached the KKM. Multirepresentation-based teaching materials could be used as an alternative to understanding abstract of chemical material and adding knowledge related to chemical concepts in various forms of representation. Chemical learning was essentially described at three different levels of representation, namely at the macroscopic, sub-microscopic and symbolic level (Chittleborough and Treagust, 2007). Macroscopic level, which is a chemical phenomenon that can be observed directly including events in everyday life (Treagust, *et al.,* 2003). Microscopic level, which is a chemical phenomenon that is not easily seen directly, and is usually depicted by atomic theory of matter, in terms of particles such as electrons, atoms and molecules which are generally related to the molecular level (Davidowitz, *et al*., 2010). Symbolic level, is a representation of various chemical phenomena through models, drawings, algebra, and computational forms (Johnstone in Treagust, *et al.,* 2003).

This study aim to analyze the understanding of the concept of acid-base students in the enrichment program.

2. Research Method

The research was carried out in one of the State High Schools in Kudus Regency involving 49 students from second grade science class which completed acid-base material. The sampling technique was carried out by *purposive sampling*. The type of research was a case study using qualitative quantitative methods. The independent variable in the research is enrichment learning assisted by multi-representation teaching materials. The dependent variable is the students' conceptual understanding. Researchers give treatment to students who complete the acid-base material in the form of enrichment learning assisted by multi-representation teaching material. Before and after being treated, the students were given a test using *three tier multiple choice questions*.

Data collection methods used are test methods and documentation. *Posttest question* given in the form of reasoned multiple choices that have been adjusted to the material indicators and concept understanding indicators totaling 20 questions. The problem has been tested beforehand to find out the validity, power difference, level of difficulty, and reliability. Analysis of concept understanding uses data combination answers to test questions consisting of understanding the concept (PK), lack of understanding of concepts (KPK), misconceptions (M), guessing (MB), and not understanding concepts (TPK). The analysis technique used is by calculating the percentage score of students 'concept understanding using the formula as follows:

$$PK = \frac{\sum \text{siswa paham konsep}}{\sum \text{soal x } \sum \text{siswa tes}} \times 100\ \%$$

Next, determine the criteria of the average percentage based on Table 1.

TABLE 1: Qualification of test results.

Range of scores (%)	Criteria
$66.68 \leq Z \leq 100$	Height
$33.34 \leq Z \leq 66.67$	Medium
$0 \leq Z \leq 33.33$	Low

3. Result and Discussion

Implementation of this research required three face-to-face meetings (3x2jp), namely the first met of students work on pretest questions to determine the level of students' ability to understand concepts. The first met after the pretest was held, students were also given the task of compiling a summary of the contents of the multi-representation acid-base enrichment teaching materials that had been distributed, so that during the second met students had known or read the contents of the teaching material. The second met, researchers conducted treatment towards students by providing multi-representation acid-base enrichment teaching materials after the pretest. Students read, analyzed, and discussed teaching materials that have been given. The researcher explains and accompanies students during enrichment learning. The next met was posttest to be done by students. The questions given at the same pretest and posttest were 20 questions with three tier multiple choice type.

The results of the study in the form of answers to pretest and posttest questions that analyzed the concept understanding of each item. Conceptual understanding analysis use a combination of answers to test questions. Interpretation of the combination of the answers to the test were shown in Table 2.

Interpretation of the combination of the answers as the basis for analysis for conceptual understanding. Analysis of students' conceptual understanding was recapitulated based on each item problem and each conceptual understanding indicator at the pretest and posttest. Indicators about each problem were presented in Table 3 and the distribution of matter indicator understanding of the concept presented in Table 4.

Table 2: Interpretation of the combination of the answers.

1	2	3	Categories
True	True	Sure	Understand Concept
True	True	Not sure	Less Understand Concept
True	False	Sure	Misconception
True	False	Not sure	Guessing
False	True	Sure	Misconception
False	True	Not sure	Guess
Wrong	Wrong	Sure	Misconception
Wrong	Wrong	Not sure	Not Understand Concept

(Suhendi *et al.*,2014)

Table 3: Problem Indicators.

No.	Indicator	Questions Number
1	Development of acid-base concept	1, 2, 3, 10, 14, 15
2	Identification of acid-base	4, 20
3	Acid strength	5, 11, 12, 13
4	Calculation of pH	7, 8, 9, 16, 19
5	Concept of pH in life	6
6	Reaction of neutralization	17, 18

Table 4: Distribution of questions about indicators of conceptual understanding.

No	Indicator Understanding Concept	Questions Number
1	Re-state a concept.	14
2	Classifying objects according to certain properties.	2, 10, 20
3	Give examples and non examples of concepts.	3, 6
4	Presenting concepts in various forms of mathematical representations.	1, 4, 7, 8, 11, 15, 16, 17
5	Developing necessary requirements or sufficient requirements from a concept.	12, 13
6	Use, utilize, and choose certain procedures.	9, 18
7	Apply problem solving concepts or algorithms	5, 19

Based on Table 3 and Table 4, each problem has represented each material indicator and concept understanding indicators. The material analyzed was acid base. One item has met the criteria for the question indicator on acid-base material and meets the indicator of students' conceptual understanding. Recapitulation of students' conceptual understanding of each item at the pretest is presented in Table 5 and recapitulation of students' conceptual understanding of each item in the posttest is presented in Table 6.

Table 5: Recapitulation of students' conceptual understanding of each item at pretest.

Problem Number	Criteria				
	PK	KPK	M	MB	TPK
1	18	3	16	9	3
2	27	9	12	1	0
3	15	3	24	3	4
4	34	1	11	1	2
5	32	1	14	1	1
6	30	3	14	0	2
7	1	5	26	5	12
8	27	6	13	0	3
9	3	2	23	18	3
10	9	2	20	8	10
11	8	2	18	8	13
12	2	7	24	5	11
13	8	7	23	9	2
14	19	0	21	6	3
15	23	7	13	3	3
16	9	7	24	2	7
17	30	2	12	3	2
18	3	10	24	4	8
19	24	2	14	3	6
20	44	1	4	0	0

The results of the analysis obtained at the pretest, namely the lowest conceptual understanding, are found in item number 7, that was only 1 out of 49 students (2%) who understod the concept so that most students experience misconceptions with a percentage of 53.1% and others less understand the concept, guess, not understand concepts with successive percentages of 10.2; 10.2; and 24.5%. Item number 7 included an indicator of conceptual understanding of presenting concepts in various forms of mathematical representation and calculation of the pH of acidic solutions. The number of students who experienced misconceptions in item number 7 because there was still confusion in determination of the value of the degree of acidity (pH) of polyprotic acid compounds which have more than one price of Ka. The lowest conceptual understanding was also shown in item number 12, where there were only 2 out of 49 students (4.1%) who understood the concept. Most students experienced misconception with a percentage of 49% and others less understand the concept, guess, do not understand the concept with successive percentages of 14.3; 10.2; and 22.4%. Question item number 12 included an indicator of understanding the concept of developing

Table 6: Recapitulation of students' conceptual understanding of each item on the posttest.

No	Criteria Criteria				
	PK	KPK	M	MB	TPK
1	45	0	3	1	0
2	43	1	5	0	0
3	28	4	16	0	1
4	37	0	11	1	0
5	44	0	5	0	0
6	37	1	11	0	0
7	31	3	15	0	0
8	34	1	10	0	4
9	33	5	8	3	0
10	36	1	11	1	0
11	33	0	16	0	0
12	22	0	27	0	0
13	24	2	22	1	0
14	26	0	22	0	1
15	46	0	3	0	0
16	29	5	15	0	0
17	44	0	4	1	0
18	24	1	19	5	0
19	32	0	12	5	0
20	47	2	0	0	0

Description: PK = Understand the Concept; KPK = Less Understand the Concept; M = Misconception; MB = Guess; TPK = Not Understand the Concept

necessary requirements or sufficient conditions of a concept. Students' misconceptions in item number 12 happened in the students' errors when determined the order of acid strength based on the picture or illustration of the acid ionization reaction presented. The possibility of students having difficulty in identifying the illustration of the ionization reaction that has been presented as in Figure 1. Students only know that the order of the strength of the acid was identical to the price of the acid ionization constant (Ka).

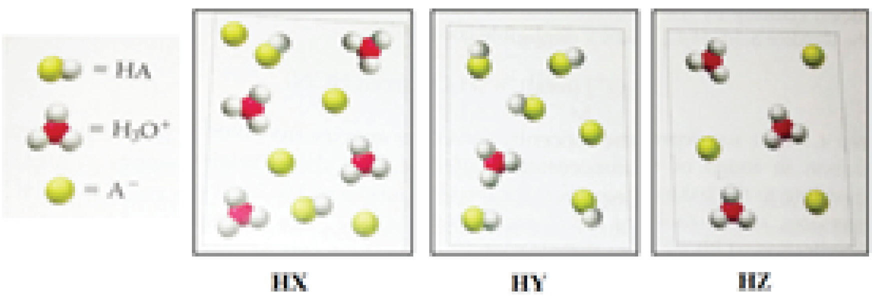

Figure 1: Illustration of acid ionization reactions.

In addition to items number 7 and 12, there was still a low conceptual understanding in item number 9 with the proportion of 3/49. Question item number 9 included an indicator of understanding the concept of using, utilizing, and choosing certain procedures. Most students experienced misconceptions with a percentage of 47% and others less understand of concept, guess, not understand concepts with successive percentages of 4; 36,7; and 6.2%. The form of item number 9 was determined the alkyl group X on the X-COOH compound if it was known the mass of X-COOH, the volume of water as solvent, pH of X-COOH, and the price of Ka of the compound. Students still have difficulties in solving the calculation of acidity (pH) with complex questions. The highest conceptual understanding at pretest was in item number 20 with the proportion of 44/49, so that only a small percentage experienced misconception (8.2%), less understand of the concept (2%), guess (0%), and not understand the concept (0%). Item number 20 included an indicator of understanding the concept of classify objects accorded to certain characteristics accorded to the concept. The high conceptual understanding in item number 20 was that students could understand the identification of acid-base solutions with litmus paper. Item number 4 also has a high conceptual understanding, namely the proportion of 34/49 and indicator of conceptual understanding that presented concept in various forms of mathematical representations. Question item number 4 contained the determination of the pH value based on the pH scale of various indicators. This high conceptual understanding indicated that students have been able to determine and conclude the pH value based on the of scales of several indicators. The existence of practicum that has been done by students related to the acid-base indicator sub-chapter can be used as one of the factors caused the high understanding of students' concepts in items number 20 and number 4.

The results of posttest, there was an increase in conceptual understanding of items number 7, 12, 9, 20 and 4. Question number 7 has an increase in the number of students who understood the concept, namely from 1 to 31 students, resulting in 11 misconceptions, from 26 to 15 students. The increase in the number of students who understood the concept in item number 7 was supported by the content contained in the teaching material that was about detailed explanation and examples of polyprotic acid problems. The same thing happened to items number 12, 9, 20, and 4 which experienced an increase in conceptual understanding after *posttest*. Item number 12 has experienced an increase in conceptual understanding due to the presence of microscopic and symbolic explanations on acid-base ionization reactions in teaching materials. During enrichment learning, deepening of acid-base material was carried out, especially in sub-chapters that were not yet understood by students with the help of multi-representation-based enrichment teaching material. Understanding the microscopic and symbolic levels will make it easier for students to learn chemical concepts in their entirety and comprehensively. This shows that to produce an understanding of the whole chemical concept, it was necessary to give or deliver the three aspects of chemical representation during the learning process in an integrated and proportional manner (Jefriadi, *et al*., 2012). Besides increasing the conceptual understanding, there was also a decrease in misconceptions in this research. This is probably because of the use of microscopic representation in chemistry learning could provided students with a complete and comprehensive conceptual understanding, so that students did not make their own interpretation in providing a microscopic picture. Most misconceptions occured in chemistry caused by students' inability to visualize images at the microscopic level (Tasker and Dalton, 2006). Microscopic representation can also improve students' memory, because with the explanation at the microscopic level the understanding obtained by students becomes intact at three levels of representation (Devetak, *et al*., 2004). The recapitulation of the distribution of conceptual understanding categories throughout pretest questions (%) was presented in Figure 2., and the recapitulation of the distribution of conceptual understanding categories throughout posttest question (%) was presented in Figure 3.

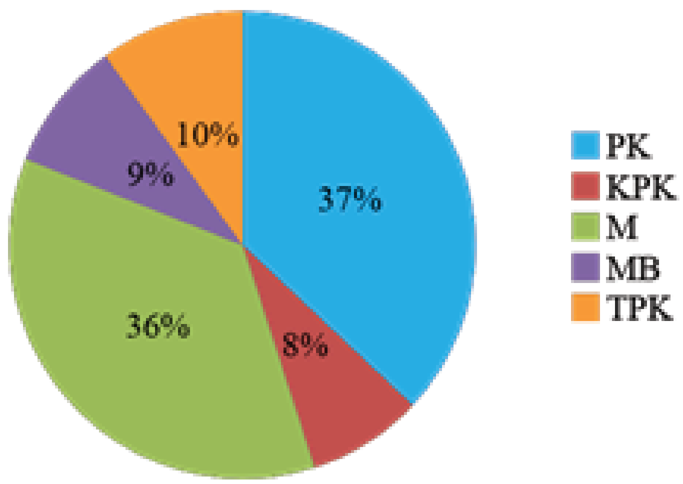

Figure 2: Distribution of Conceptual Understanding Categories for the All Pretest Questions.

Graphs of conceptual understanding of pretest and posttest questions could be seen in Figure 4.

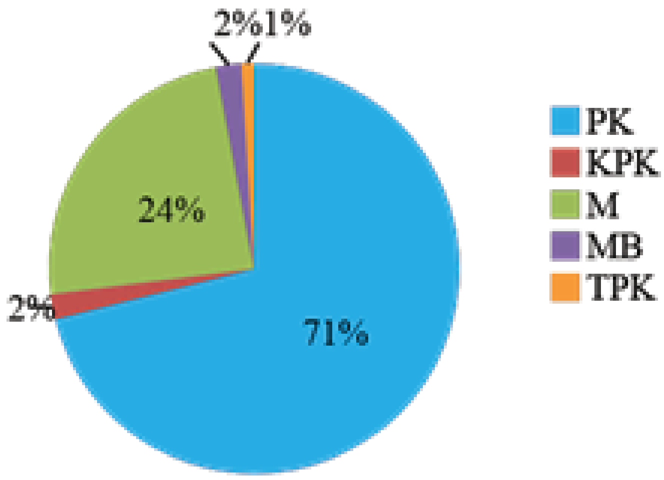

Figure 3: Distribution of Conceptual Understanding Categories for the All Postest Questions.

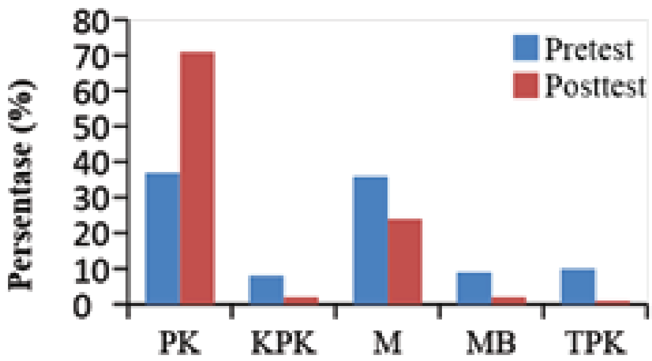

Figure 4: Graph of Conceptual Understanding of the Pretest and Posttest Question.

Based on an analysis of the conceptual understanding of all pretest questions, the percentage of the understand the concept was 37%, less understand the concept by 8%, misconception by 36%, guess by 9%, and not understand the concept of 10%. Overall conceptual understanding of all posttest questions increased in conceptual understanding that was obtained, understand the concept percentage of 71% and experienced a decrease in misconception to 24%, guess by 2%, less understand the concept of 2% and not understand the concept of 1%. Based on the results obtained, it showed that enrichment learning assisted by multi-representation teaching material could improved students' conceptual understanding. The abstractness of acid-base material could be minimized by giving an explanation through the level of microscopic representation. The microscopic level could not be separated from the other two levels of representation (macroscopic and symbolic) because it contained inter-connectedness information (Indrayani, 2013).

The results of the student answers recapitulation in the form of conceptual understanding of each indicator (%) at the *pretest* could be seen in Figure 5. While the recapitulation of students' conceptual understanding of each indicator (%) in the *posttest* could be seen in Figure 6.

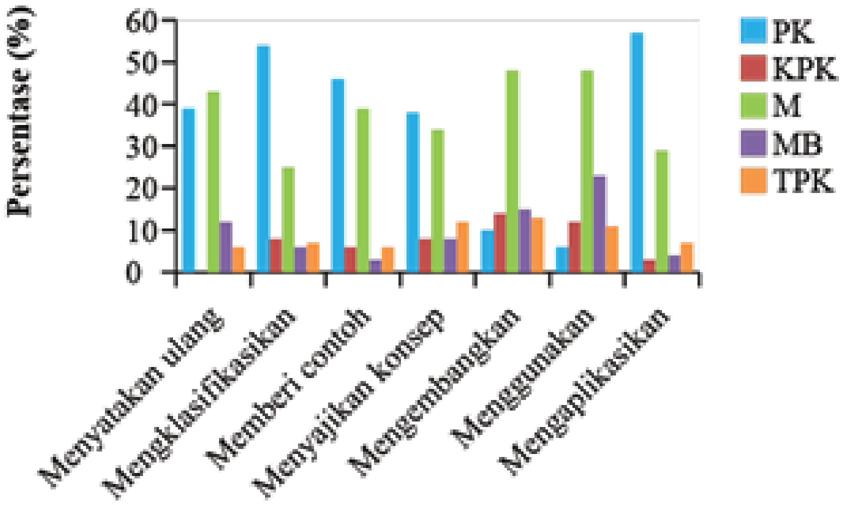

Figure 5: Recapitulation of students' conceptual understanding of each indicator (%) at the pretest.

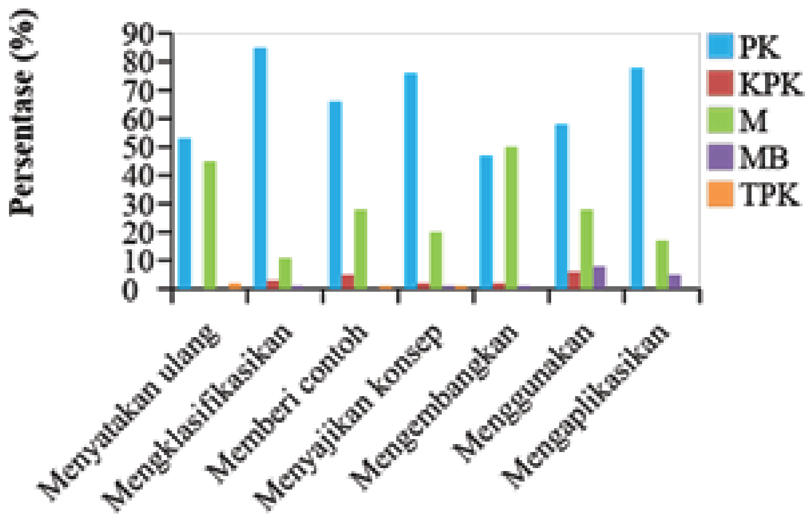

Figure 6: Recapitulation of students' conceptual understanding of each indicator (%) at posttest.

Indicators of conceptual understanding that used are restating, classifying, giving examples, presenting concepts, developing, using and applying. Based on this analysis, conceptual understanding at pretest resulted in indicators restating 39%, classifying

54%, giving examples 46%, presenting concepts 38%, developing 10%, using 6% and applying 57%. Recapitulation of students' conceptual understanding of each indicator (%) at pretest was shown in Figure 4.4 and Figure 4.5. The conceptual understanding in *posttest* experienced an increased in the percentage of each indicator, namely restating 53%, classifying 85%, giving an example of 66%, presenting the concept of 76%, developing 47%, using 58% and applying 78%. Indicator of conceptual understanding that have the highest percentage after getting enrichment assisted by teaching material was classifying with a percentage of 85%. The high percentage of classifying indicator was supported by the contents of the teaching material about the discussion that was multi representation (macroscopic, microopic, and symbolic) made students were able to classify objects. The developing indicator getting the lowest percentage that was 47%. The developing indicator contained in the teaching material are sufficient, that contained an explanation of the microscopic parts of some acid-base sub-materials and some examples of problems that were quite complex. Devetak, *et al.*, (2007) states that by giving a microscopic representation in the chemistry learning process can help students to develop conceptual understanding in depth and be able to develop problem-solving abilities. However, the result of developing indicator has the lowest percentage. One of the causes is the motivation of students in understanding the example of the problem and doing the exercises so that more motivation is needed to increase students' motivation in doing the exercises.

4. Conclusion

The conceptual understanding of second grade science students in State High School in Kudus who participated in the enrichment program on acid-base material was high. Achievement of students' conceptual understanding has increased seen from the results of preteset and posttest namely from 37% to 71%. Overall enrichment learning assisted by multi-representation teaching material was effectively used in learning so that the achievement of students' conceptual understanding of acid and base material consisted as the high category.

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