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CORRECTING STUDENTS' MISCONCEPTION IN ACID AND BASE CONCEPT USING PDEODE INSTRUCTION STRATEGY

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Abstract

This study aimed (1) to calculate the percentage of students who understand concepts, having misconceptions, and don't understand concepts, (2) to identify students' misconceptions of acid and base concept, and (3) to test the effectiveness of PDEODE (Predict-Discuss-Explain-Observe-Discuss-Explain) instruction strategy in correcting students' misconceptions of acid and base concept. This research uses descriptive and pre-experimental one-group pretest-posttest design. The sample consisted of 37 students of 11th grade IPA 4 MAN 1 Kudus. The misconceptions are identified using modified CRI (Certainty of Response Index) techniques and explored through semistructured interviews to get deep informations. The effectiveness of PDEODE instruction strategy was determined from the analysis of paired samples t-test. The results of this study are: (1) the level of students' misconception of acid and base concept changed significantly after was repaired by PDEODE instruction strategy and (2) there were 45 kinds of students' misconceptions of the subconcepts: characteristics of acids and bases, acid and base theories, strength of acid and base, neutralization reaction, and pH of solution.

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INTRODUCTION

Chemistry is branch of science that studies the properties of compounds and reactions of substances change (Oxtoby *et al*, 1999). One of the chemical topic taught in senior high school is acid and base. This topic is important for student to master because it contains basic concept of chemistry. In reality many students have difficulties and problems in understanding the concept. The difficulty arises from the characteristics of chemistry that not only abstract and complex (Stieff & Wilensky, 2003), but also involves three levels of representation, i.e. macroscopic, submicroscopic and symbolic (Gilbert *et al*, 1982). In addition, Muchtar & Harizal (2012) revealed four major problems of students in understanding acid and base, that are (1) fragmentation of students' understanding, (2) improper use of symbols and mathematical formulas, (3) neglect the real context of chemistry, and (4) generalization of the problem. Beside those, the problems also arises from the initial conception of students who deviate from the scientific conception.

Based on the preface research in the 11th grade of MAN 1 Kudus, it was be found that 72% student didn't pass the passing grade in acid and base concept. From short interview, it was known that they have lack on calculation, missing basic concept and misunderstanding on concept application. All of those problems can lead to misconceptions. Misconception is the idea/ view that does not correspond with the idea/ view that has been accepted by the scientific community (Demircioglu *et al*, 2005).

Misconceptions can interfere students to understand concept, especially basic concepts like acid and base. To overcome this, firstly the misconception have been identified. However, in the process of identifying misconceptions, it is difficult to distinguish between students who have misconception, who just guess the answer because they does not understand the concept (lack of knowledge), and who really understand the concept well. For that, it is needed a technique that is sensitive to distinguish among them. One of the technique that can be used is modified Certainty of Response Index (CRI) that developed by Hakim *et al* (2012).

Misconceptions that have been identified need to look for corrections. It required a teaching which could accommodate the changes of students' concept. Posner *et al* (1982) suggest that the changes of concept can be held if four conditions are fulfill, they are (1) students' dissatisfaction to the misconceptions, (2) easiness of right concept to understand (intelligibility), (3) the right concept more reasonable (plausibility), and (4) the right concept can provide a better solution to the existing problems (fruitfulness).

One of the strategy that can be used to support the change of concept is PDEODE instruction strategy (Coştu *et al*, 2011). This is because the stages of PDEODE activities fulfill four conditions to make students change their misconceptions as proposed by Posner *et al* (1982) (Savander-Ranne and Kolari, 2003). It consist of six stages, which are (1) predict, (2) discuss, (3) explain, (4) observe, (5) discuss, and (6) explain. The first four activities able to confront the wrong concept to scientific one from the observation. It can make student dissatisfy with wrong concept. The three last activities, observation, discussion, and explanation can facilitate students to find variety of opinions and reasons to explain the results of observation. Teachers guide students to devote ideas and find conclusions. It makes scientific concepts easier to understand (intelligibility) and reasonable (plausibility). Students are expected to revise their wrong concept. So, students can accept and use the scientific concept (fruitfulness) to solve problems.

The strength of PDEODE lies on its ability to test the concept. The concept not only be tested through contrasting wrong concept with scientific one in observation activities, but also through the process of defense ideas in discussions/ brainstorming. Students are invited to discover scientific reasons of the phenomenon by arguing in small and large forum. Thus, students can find logical reason to change the concept.

METHODS

This study used descriptive analysis to reveal student misconceptions and pre-experimental one group pretest-posttest design to know the effectiveness of PDEODE instruction strategy to correct students' misconceptions. Table 1 below presents the pre-experimental design of this research.

Table 1. Pre-experimental Research Design

Research Class	Pretest	Treatment	Posttest
Experiment	T_1	X	T_2

Note:
T_1 : Pretest
T_2 : Posttest
X :Teaching use PDEODE Instruction Strategy

It was used convenience sampling technique. The sample in this research is 11th grade IPA 4 MAN 1 Kudus that consist of 37 student. The independent variable is PDEODE instruction strategy while the dependent variable is students' understanding of concepts. Misconceptions were identified using modified CRI techniques. The test was objectives test consisted of four options and one empty answer that can be filled by students if the four options didn't match with students' conceptions. Students were also asked to write the reason of choosing it and determined the CRI or level of confidence in answering the questions. The criteria of CRI presented in Table 2.

Table 2. Criteria of CRI

Scale of CRI	Criteria
0	Totally guessed answer
1	Almost guess
2	Not sure
3	Sure
4	Almost certain
5	Certain

(Hasan *et al*, 1999)

Hakim *et al* (2012) sets out some provisions to categorize students who understand the concept, having misconceptions, and do not understand the concept. Such provisions are summarized in Table 3.

Instruments in this research were scenarios of learning, worksheet, and manual laboratory. Instrument of data collector consisted of written test and interview guidelines. Semistructured interviews were conducted after pretest and posttest at 9 students with different levels of pretest scores. Based on the expert validation, it obtained 92.2% for average validity of learning scenarios, worksheets, and instructions for practical implementation and 91.67% for written questions test. The test results showed that from 30 questions items, 24 question were valid and had 0.914 of reliability index. The null hypothesis of this research is there isn't significant difference of students' conceptual understanding between before and after giving PDEODE instruction strategy. Thus hypothesis was tested using paired samples t-test.

Tabel 3. Terms CRI Modified for Each Answer Given

Answers	Reasons	CRI value	Description
True	True	> 2.5	Understand the concept of well
True	True	< 2.5	Understand the concept but are not confident with the answers given
True	False	> 2.5	Misconceptions
True	False	< 2.5	Do not know the concept
False	True	> 2.5	Misconceptions
False	True	< 2.5	Do not know the concept
False	False	> 2.5	Misconceptions
False	False	< 2.5	Do not know the concept

(Hakim *et al*, 2012)

RESULTS AND DISCUSSION

From the results of pretest and posttest, students were grouped into three parts, which were students who understand concept, having misconceptions, and didn't understand concept. The percentage of students' understanding concept of the three groups on pretest were exposed in the Figure 1.

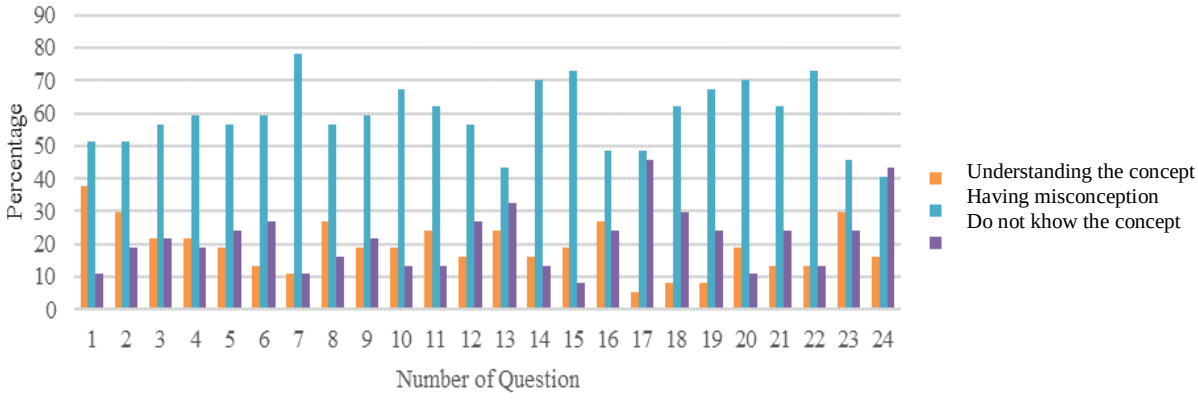

Figure 1. Presentation of Students' Understanding on Pretest

Figure 1 above shows that students have low understanding of concept. The results of interview also shows that students are less able to associate concept of acid and base with daily life. For example, many students assume that CH_3COOH (vinegar) is base because the molecular formula has OH. Whereas in the daily life, students often interact with vinegar for consumption. It meant that the learning activities in class didn't make student connecting the materials with their daily things yet. Unsynchronicity chemistry learning with daily life is also expressed by Aikenhead (2003) and Shen (1993) as one of the reasons why students do not understand concept of chemistry well.

The results of the pretest also showed that more than 50% of students having misconceptions. Students have variety of assumptions, such as only acid/ base/ strong acid and strong base solution that can conduct electricity. One of the misconceptions is reflected in the interviews between investigators (I) and student (S) below.

I : "Among the following solutions (listed on the interview guides) which one can conduct electricity?"

S : "What is $C_{12}H_{22}O_{11}$ Mom?"

I : " $C_{12}H_{22}O_{11}$ is sugar"

S : "I think only HCl and NaOH that can conduct Mom"

I : "Why?"

S : "Because they both are strong acid and strong base Mom. Only strong solutions that can conduct electricity. Strong solution make ionic current flow strongly, so it can conduct electricity. If others can not Mom ".

The second concept is acid-base theory. Many students state that compounds containing hydrogen element in their molecular formula are classified as acid whereas all compounds containing OH are classified as base. Moreover, not a few students who incorrectly use the definition of acids and bases according to the Arrenius theory, Bronsted-Lowry, and Lewis as well as acid-base conjugate. The high percentage of students who have misconception on acid-base theory was also reported by Artdej *et al* (2010). Here are excerpts of interview with one of the students who have misconception.

I : "Consider to the following compound group! (While showing the sheet contains group of several compounds) Which one is classified as Arrhenius acid? "

S : "B (pointing to group that consist of HCl, HBr and NH_3 compounds)"

I : "Why are that compounds referred to acid?"

S : "Because they have H Ma'am"

I : "So do you think that all compounds with H in their molecular formula are identified as acid?"

S : "Yes Ma'am. To detect easily it is acid or not, Ma'am "

I : "In your opinion, what is Arrhenius acid?"

S : "The Arrenius acid is compound that donate proton"

I : "Next, notice this compound! (While showing the sheet contains groups of several compounds) What is/ are compound that belong to the Arrhenius bases? "

S : "KOH, $Ba(OH)_2$ and HCOOH"

I : "Why?"

S : "Because they have OH Ma'am"

I : "So, do you also think that all of compound that have OH in their molecular formula were identified as base?

S : "Yes, Ma'am. I usually use that to distinguish them"

I : "So, what do you think about Arrhenius bases?"

S : "Arrhenius bases is compound that accepts protons."

The third concept is the strength of the acid-base. Based on the experiment, it was showed that students have misconceptions in determining: (1) species contained in a solution, (2) the relationship between value of K_a with the power of ionization of acid and the relationship between the value of K_b with the power of base ionization, (3) factors that affect the strength of acid, (4) the difference between strong acid and weak acid, and (5) the determination of the value of pH of acid compounds with the same concentration.

The fourth concept is neutralization. There are students who think that the addition of a weak acid solution to a strong base will make the basicity of strong base solution increases. There are also students who thought that the base neutralization reaction with strong acid/ weak acid has no effect on its basicity.

The fifth concept is pH. Most students believe that the dilute acid has pH greater than 7, while the dilute base having pH less than 7. They are not aware the basic principle of pH that acid has pH fewer than 7 and base has pH greater than

7 at room temperature and pressure. They have stick on the calculation of pH using the formula that pH is logaritma of H^+ ion concentration of HCl in solution. They didn't add the H^+ ion concentration of water. In addition, many students thought that acid/ base that diluted/ concentrated are not going to make the value of pH's solution changes. Students also have misconceptions in explaining the concept of color changes in red and blue litmus paper when used to detect the nature of acid/ base solution.

From the results of the pretest and deep interview, it can be identified all of students's misconceptions. Table 4 below summarize students' misconceptions in acid and base concept.

Table 4. Students' Misconceptions in Acid and Base Solution

Concept	No.	Misconceptions
Characteristic of acid and base	1.	Only acid solution that can conduct electricity.
	2.	Only strong acid and strong base solution that can conduct electricity.
	3.	Only base solution that can conduct electricity.
	4.	Acid solution can't react with aluminum.
Theory of acid and base	5.	Compounds with hidrogen in their molecular formula are acid.
	6.	Compounds with hydroxide in their molecular formula are base.
	7.	According to Arrhenius, acid is compound that donate proton.
	8.	According to Arrhenius, base is compound that accept proton.
	9.	According to Arrhenius, acid is compound that accept electron pair.
	10.	According to Arrhenius, base is compound that donate electron pair.
	11.	According to Bronsted-Lowry, acid is compound that donate electron pair.
	12.	According to Bronsted-Lowry, base is compound that accept electron pair.
	13.	Conjugate acid is acid that made when acid react with base, meanwhile conjugate base is base that made when base react with acid.
	14.	Lewis acid is compound that can release H^+ ion in water, meanwhile Lewis base is compound that can release OH^- ion in water.
The strength of acid and base	15.	Lewis acid is compound that its product have positif charge, meanwhile base is compound that its product have negative charge.
	16.	Species in HCl solution are H^+ ion and HCl.
	17.	Spesies in NH_3 solution are NH_4^+ ion and OH^- ion.
	18.	Spesies in NH_3 solution are N^+ ion and H^{3-} ion.
	19.	Spesies in NH_3 solution are NH_3 dan OH^- ion.
	20.	Spesies in H_3PO_4 solution are H^+ ion dan $H_2PO_4^-$ ion.
	21.	Spesies in H_3PO_4 solution are H^+ ion, $H_2PO_4^-$ ion, HPO_4^2, dan PO_4^{3-} ion.
	22.	Spesies in H_3PO_4 solution are H^+ ion, $H_2PO_4^-$ ion, HPO_4^{2-}, dan H_3PO_4.
	23.	Spesies in H_3PO_4 solution are H^+ ion, $H_2PO_4^-$ ion, PO_4^{3-} ion, dan H_3PO_4.
	24.	Spesies in KOH solution are K^+ ion dan KOH.
	25.	Acid with low K_a ise strong acid.
	26.	Acid with lower K_a has higher ionization ability and base with lower K_b has higher ionization ability.
	27.	The factor that influence the strength of acid is the number of H atom.
	28.	The factor that influence the strength of acid is concentration of acid.
	29.	The factor that influence the strength of acid is pH.
	30.	The difference between strong acid and weak acid is strong acid has more number of hydrogen bonding than weak acid.
	31.	The difference between strong acid and weak acid is strong acid has higher pH than weak acid
	32.	The difference between strong acid and weak acid is strong acid has higher concentration than weak acid.
	33.	In the same concentration, pH of weak acid < pH of strong acid with valence 1 < pH of strong acid with valence 2.
	34.	In the same concentration, pH of weak acid = pH of strong acid with valence 1 = pH of strong acid with valence 2.
	35.	In the same concentration, pH of strong acid with valence 1 = pH of strong acid with valence 2.
	36.	In the same concentration, pH of strong acid with valence 1 < pH of strong acid with

Concept	No.	Misconceptions
		valence 2.
Neutralization	37.	Adding weak acid solution to the strong base solution make basicity of strong base increase.
	38.	Adding strong acid/ weak acid solution to the strong base solution make basicity of strong base increase.
pH	39.	Dilute acid solution has pH more than 7 and dilute base solution has pH lower than 7.
	40.	If acid/ base solution made be dilute/ concentrated, so the pH will be stagnant.
	41.	If base solution concentrated so pH of the solution will be decrease.
	42.	Sugar and lime solutions are acid.
	43.	If base solution test with litmus, red litmus will still red and blue litmus too.
	44.	Solution with $[OH^-] > [H^+]$ is acid.
	45.	Acid solution make blue litmus still blue.

The identified misconceptions in Table 4 were also reported by the other researcher like Demircioglu *et al* (2005), Chiu (2005), Sheppard (2006), Pinarbasi (2007), Ross & Munby (2007), Demircioglu (2009), Cetingül & Geban (2011), Rahayu (2011), Mayestika (2011), Yalcin (2011), Efendi (2012), and Ozmen *et al* (2012). It could be seen that student have misconceptions almost in all of acid and base concepts. There are many things that make student have misconceptions. First, students are less able to associate the concepts with their daily life. In addition, students are also having fragmented understanding, where students are not able to associate the concept is being studied with a concept that has been previously learned. Misconceptions also occur because student generalize rules/ theory/ formula to resolve some problems without having deep understanding the limitations of them.

After learning activities using PDEODE strategy, there is significant change of the students' percentage who understand the concept. It shows in Figure 2.

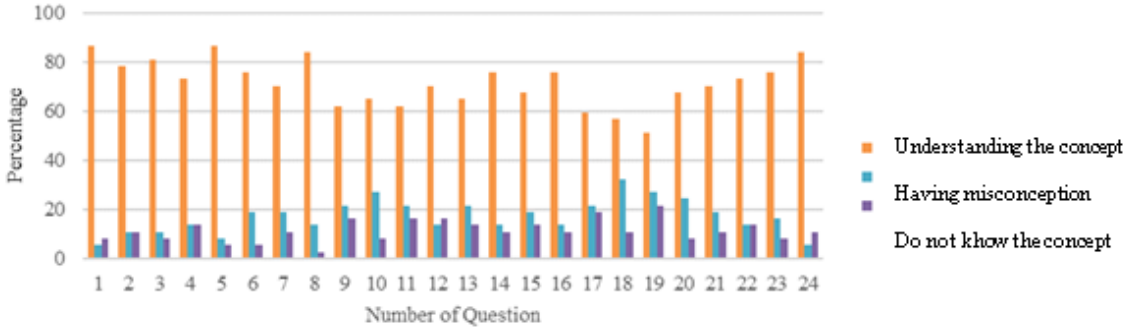

Figure 2. Presentation of Students' Understanding on Posttest

From those pictures, it can be seen that percentages of students who understand the concept, having misconceptions, and do not understand the concept changed significantly from pretest to posttest. In general, students increased scores from pretest to posttest. To test the hypothesis, it was used paired sample t-test. It showed that the scores of pretest and posttest differed significantly (0.000) < (0.05). It indicated that there was a significant difference between the understanding of concept (test scores) of students before and after repair using PDEODE. It meant that PDEODE instruction strategy effective to correct students' misconceptions.

According to Coştu *et al* (2011), PDEODE learning strategy is effective to correct students' misconceptions because its six steps are able to help students evaluate their misconceptions and reexamine ideas (prediction) in small and large group discussions / class. Yumiati (2015) adds that after students receive the correct concept, students associate the new concepts with relevant concepts so the learning becomes meaningful.

PDEODE learning strategies have also been qualified to be strategy of change concept by Posner *et al* (1982). It can be seen from the activities like prediction, discussion, explanation, and observation that is able to confront the wrong concept to the scientific concept in observation

activity. It can make students dissatisfy with initial knowledge. The next activity, discussion and explanation are able to facilitate students to find the variety of opinions and reasons to explain the results of observation. Teachers guide students to devote ideas and find conclusions. It makes available scientific concepts easier to understand (intelligibility) and reasonable (plausibility) so that students can revise their wrong concept easily. From that, scientific knowledge become useful (fruitfulness) for students to solve the problems. The effectiveness of PDEODE learning strategy on correcting students' misconceptions consistent with research were conducted by Coştu (2007), Coştu *et al* (2011), Solichah *et al* (2014), Sugiarti & Nasrudin (2015), Dewi & Suhandi (2016), and Demircioglu (2017).

CONCLUSION

Based on the discussion, there are some conclusions, (1) there has been a significant change in the level of students' misconceptions on acid and base solution after repaired use of PDEODE instruction strategy, they are a) the results of the pretest showed 19% understood the concept, 59% had misconceptions, and 22% didn't understand the concept; b) post-test results showed 72% understood the concept, 17% had misconceptions, and 11% didn't understand concept; (2) it was found 45 kinds of misconceptions on the concepts of : a) the characteristics of the acid-base solution, b) acid-base theory, c) strength of the acid-base, d) neutralization reaction, and e) pH of the solution.

This research can be developed into wider area. The other researcher can identify students' misconceptions using modified CRI technique in the other topic and improve it with PDEODE instruction strategy. Besides that, the other strategy that conduct for correcting students' misconceptions also can be tested into this topic or others.

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