Students' Misconceptions on Titration

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Abstract. Misconceptionscanlead to the problems of students' understanding, if it is not resolved immediately. Through this research, the potency of misconceptions has been investigated on analytical chemistry subject, especially on titration concepts. Descriptive method was used in this study, involving 66students who were takingAnalytical Chemistry course. The seven items of multiple choice tests with reasons were used as an instrumentand the result was then analyzed on using modified CertaintyofResponseIndex technique. The results show that 51.6% of students understand the concepts of titration well; 13.3% of students do not understand the concept, and 35.1% of students have misconceptions. The misconceptions mainly occurred in macroscopic and symbolic levelofrepresentation on choosing measuring equipment for titration, using titration equipment, and calculating titration.

1. Introduction

Titration concept has been taught to students since at senior high school. Students' understanding of the titration process can vary depend on their own knowledge and experience. Some students' do not understand, but some others face on misconceptions. Misconception may occur to students if the understanding of concepts does not correspond to the actual concepts[1,2].Louga et al.[3]also stated that misconception is inconsistency between students' views and experts' views.Misconceptions will lead to problems affecting students' understanding level if not resolved immediately. Misconceptions may be occurred in chemistry. Many researches have been done to anticipate the potential misconceptions, because misconceptions always arise in lectures.

Pinarbasi[4]reported misconception on colligative properties subject, and advised that the strategies of learning should be applied on using substantial review. Moreover, Yarroch (in Nakleh[5]) has carried out the research on misconceptions associated with chemical reaction.He reported that all students managed to equalize the equation, but most students could not draw molecular diagrams correctly to explain the similarities sub-microscopically. Regarding the size of atoms, Eymur et al.[6] reported that students who are prospective teachers have misconceptions which are almost similarly experienced by high school students. Misconceptions are highly dependent on many factors, such as experience, creativity, perception, and textbooks.

Pinarbasi[7] reported that Turkish students have a number of common misconceptions on the topic of acids and bases. The same research of misconceptions on acidsand bases has performed by Demircioglu et al.[8]Rahayu et al. [9], Damanhuri et al. [10], and Tumay [11]. Pan &Henriques [12]at least the six types of misconceptions on acids and bases concepts were proposed.The type of misconceptions that mostly occurred was the notion that the endpoint or equivalence point of a titration is always at pH 7.

Misconceptions on titration concepts need to be studiedbecause it is a basic concept for learning analytical chemistry.Research on acid-base titrationlearning of students in junior hight school has been reported by Sheppard [13]. The results indicated that students have major difficulty on acid-base concept as well as they were not able to accurately describe the concept of acid-base, such as pH, neutralization, acid-base strength, and acid-base theory. Several factors contribute to these difficulties;basics of chemistry on acid-base are too visceral, with more emphasis on mathematical calculations for learning and textbooks-dependent. The density of acid-base concept, the confusing acid-base terminology and lack of consensus on what material should be included in the curriculum of chemistry were also identified as problems. Widarti et al. [14] reported that they found misconceptions on redox titration, where misconceptions occurred on concepts involving concentration measurements with chemical equation, species existing in solution from titration process, and the characteristics of redox titration involving potential calculation.

A research on titration was carried out involving 38 students who were taking basic analytical chemistry (BAC) course. The study showed that despite the students' ability in BAC was considered as fair in category, but three times tests indicated significant deterioration (the score respectively 72.79; 66.00; and 59.00). Based on the research on students' answers, they are generally weak in mathematics literacy and ability to provide relevant analysis of how to determine the choice of indicators in a titration (Widarti et al. [15]). It is highly associated with a students' low ability in explaining phenomenon in a submiscroscopic and symbolic way. Therefore, a research is done to investigate students' misconceptions on the concept of titration.

2. Experimental Method

Descriptive method was used in this research. The subjects of research were 66 students in the 3rd semester of Chemistry Education from 2014-2015 batch in a university in East Java. Misconceptions in the study arerevealed by the merger of two instruments that have been developed, namely the multiple-choice test of 7 questions on the concept of titrationwith open reason and Certainty of Response Index (CRI) technique by Hasan, et al. [16] which has been modified. The technique can distinguish among knowing the concept well, not knowing the concept and having misconceptions.The reasonings is needed as a reflection of their thinking and understanding of the proposed concept. From the answers and the reasonings, the congruence of students' understanding with the scientific concept can be discovered.The characteristics of the misconceptions are durable, firmly entrenched in ones' mind (Louga, 2013). Relates to personal belief, so the used of used CRI techniques is relevant to reveal student misconceptions.

The modified CRI, as proposed by Hakim et al. [17], was used to accommodatebiasfrom Indonesian student culture. Mostly, students understand concept but not confident whit their answers, show the adding reasoning in every students' answer will help to analyze data. According to Kurbanoglu et al. [18], students who master the concept well also have high confidence.The modification of CRI scaling was also performed as recommended by Potgieter et al. [19], by using four scales (1-4), 1 = guessing, 2 = not certain, 3 = certain, 4 = very certain.

Based on the answers, reasonings and CRI, there are some possibilities happening. If students' answer is correct with correct reasoning and with CRI>2, then students are classified as understanding the concept well. If students' answer is correct with correct reasoning but with CRI<2, students are still classified as understanding the concept well. If students' answer is wrong with correct or wrong reasoning and with CRI>2, then students are classified as having misconception. If students' answer is wrong with correct or wrong reasoning and with CRI<2, then students are classified as not understanding the concept. If students' answer is correct with wrong reasoning and with CRI<2, then students are classified as not understanding the concept. Possibilities in utilizing modified CRI for each of students' answer are as seen on Table 1.

Table 1. Classification of modified CRI on students' answers (Hakim et al. [17], Potgieter et al. [19])

Answer	Reasoning	CRI	Description
True	True	> 2	Understand the concept well
True	True	<2	Understand the concept but not certain of the answer given
True	False	> 2	Misconception
True	False	<2	Not understand the concept
False	True	> 2	Misconception
False	True	<2	Not understand the concept
False	False	> 2	Misconception
False	False	<2	Not understand the concept

3. Results and Discussion

Data test on volumetric analysis in BAC course reflected the students' skills level. Each student has different level of comprehension and understanding of concepts although they study the same material with the same lecturer. The different ability may cause the different comprehension and misconceptionsto the concepts learned.As it is stated before, titration concepts has already taught since senior high school. In reality, the BAC course could not reduce all of the misconceptions. The total number and percentage of the students' answers on titration are as seen on Table 2.

Table 2. Totalnumber and percentage of studentsmisconception on titration

No	Concept	Total and Percentage (%) of Students Having Misconception					
		Misconception (M)		Not Understand (N)		Understand (U)	
		Total	Percentage	Total	Percentage	Total	Percentage
1	Selection of equipment	29	44	4	6	33	50
2	Titration processing	10	15	3	5	53	80
3	Washing and rinsing burette	5	8	2	3	59	89
4	Washing and rinsing Erlenmeyer	42	64	3	4	21	32
5	Rinsing technique along titration	41	62	3	4	22	34
6	Selection of titration method	1	1	31	47	34	52
7	Stoichiometric titration	34	52	16	24	16	24
	Average	35,1		13,3		51,6	

Number of student: 66

As it is shown in Table 1, between the 7 testswere given, the students'answer number 4, 5, and 7 (Washing and rinsing erlenmeyer, Rinsing technique along titration, and Stoichiometric titration) lead to misconceptions (more than 50% of students). Meanwhile, almost of all student were not misconceptions on the concepts in test number 2 (Titration processing) and 3 (Washing and rinsing burette). From the answer test number 1 (Selection of equipment) and 6 (Selection of titration method), number of students who have misconceptionsis proportional with the number of students who have understand the concepts.This is encouraging that only a few students who not understand the concepts (13,3% of all students). The portrait of overall misconceptioncompare to the understand concepts is shown in Figure 1.

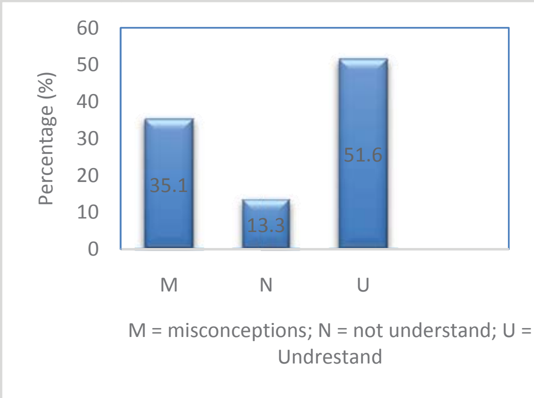

Figure1. Percentage of students' misconceptions on titration

Misconception most commonly occurred in the answer to question number 4 (64%). The questionasked:"what has to be done when provided erlenmeyer flasks has already rinsed off but not dried and it will be used immediately for titrating HCl with NaOH solution?". Most of students answer with minsconceptions potential.Students explained erlenmeyer has to be rinsed by HCl solution instead of aquadest. Some of them said that the erlenmeyer should be dried, and some other else answered to use erlenmeyer immediately. Erlenmeyer as a container for sample or titrant (HCl) has to be clean and dry.If not, it will affect the quantitative result. Wet apparatuscan be used but it must be rinsed off with aquadest. However, if the apparatus are already dry and clean, it is not need to rinse them off. When dried with tissue, erlenmeyer will become dirty because the wet tissue will stick to the erlenmeyer.

The same case also occurred on the question number 5 regarding to the process of titration. The students were asked to explain whether it is allowed to rinse erlenmeyer wall with aquadestalong titration.As many as 62% of student showed misconceptions by answering that it is not allowed because the number of substance will change. However, rinsing or adding aquadest to erlenmeyer flask do not affect the amount of substance, because the number of moles of solute (HCl) will not change regardless the addition of solvent volume. The students must understand that the number of dissolved substance or the number of moles of a solute(HCl) do not change by solvent addition. The change will only be occurred in concentration and the molarity of a solution. There is a relationship between concentration with the amount of solute.Concentration is the number of moles of solute in a volume of solution.

Moreover, Misconceptions also occur in the answer of the question number 7 (the calculation of moles of NaOH needed for titration with 10 mL 0,1 M oxalic acid solution). In student's perception, themmoles of oxalic acid is equal to mmoles of NaOH at the end point of titration, without considering the chemical equation. It is also predicted that students possibly do not know the chemical formula of oxalic acid. Actually, they have to take account into equivalence of H^+ and OH^- ions in chemical equation. Oxalic acid produces two H^+ion.The reaction between oxalic acid and NaOH is as follows:

$$2H^+ + C_2O_4^{2-} + 2Na^+ + 2OH^- \longrightarrow 2H_2O(l) + C_2O_4^{2-} + 2Na^+$$

One mole oxalic acid (produce two moles H^+) is equivalent with two moles of NaOH (produces two moles).

Test number 1 is about the equippment needed to measure the volume of sample solution for titration. As many as44% of students answer measuring pipette, not volumetric pipette to measure the volume of solution sample. The students still assume that measuring pipette has the highest accuracy in measuring the volume of a solution, instead of choosing volumetric pipette.

Most of students did not understand the concepts that should be answered in the question number 6. The concept is about titration application, especially in selection of appropriate method that can be used to determine the content of a sample containing caustic soda. Commonly, they chose the other techniques instead of acid-base titration. They proposed some reasons. Some of them thought that caustic soda can be precipitated on using $AgNO_3$ to produce silver hydroxide. Some others argued that hydroxide ion can be oxidized into oxygen gas.

Most of students have the good understand to the concepts on what to do to the washed but not dried burette when it will soon be used to titrate HCl sample with NaOH solution. Most of the students gave argument they have to rinse the burette with NaOH solution that will be used as titrant.

Based on research, there were still found some potential misconceptions on titration subject. It should not be the case because actually this concept has been studied both during senior high school as well as in basic chemistry course in graduate level. Mostly, the misconceptions occur on macro and symbolic representation. Students confused on choosing the appropriate apparatus for measuring volume of sample. Students were also ambiguous in titration calculations. This phenomena occurs in less meaningful learning as stated by Berg, Cross et al., and Pinarbasi[5,6,7]. Some researches recommend learning has to be plan with the more students active and partisipatory as well as accommodate the multiple representative especially in learning chemistry[3, 4,8, 9].The important thing is student has to have a high motivation on learning. Some strategies are recommended by some researchers, such as collaborative[20], problem possed[21], or cognitive dissonance[22]. the last strategy has not used in chemistry learning yet, so it is interest to combine the multiple representation and cognitive dissonance strategies, as a challenge interactive learning.

4. Coclusion

Misconceptions will lead to the problems on the level of students' understanding, if it is not resolved immediately. By the descriptive research involving 66 students of basic analytical chemistry course, it is shows that 51.6% of students understand the concepts of titration well; 13.3% of students do not understand the concept, and 35.1% of students have misconceptions. The misconceptions mainly occurred in macro and symbolic skills on choosing measuring equipment for titration, using titration equipment, and calculating titration.

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6. References

[1] Suparno, P 2005 *Miskonsepsi & Perubahan Konsep Pendidikan Fisika* (Jakarta: Grasindo)
[2] Van den Berg, E 1991 *Miskonsepsi Fisika dan Remediasinya* (Salatiga: Universitas Kristen SatyaWacana)
[3] Luoga, N E., Ndunguru, A P, and Mkoma, L S 2013 *Tanzania Journal of Natural & Applied Sciences* **4** pp 575‒81
[4] Pinarbasi, T, Sozbilir, M, and Canpolat N 2009 *Chemistry Education Research and Practice* **10** pp 273‒80.
[5] Nakhleh, B M 1992 *Journal of Chemical Education* **69**(3) pp 191‒6
[6] Eymur, G, Cetin, P, and Geban O 2013 *Journal of Chemical Education* **90** pp 976‒80.
[7] Pinarbasi, T 2007 *Journal of Baltic Science Education*, **16**(1) pp 23‒34
[8] Demircioglu, G, Ayas, A. and .Demircioglu,H 2005 *Chemistry Education Research and Practice*, **6**(1) pp 36-51
[9] Rahayu, S, Chandrasegaran, L A, Treagust, F D, Kita, M, and Ibnu, S 2011 *International Journal of Science and Mathematics Education*, ***9*** pp 1439-58.

[10] Damanhuri, M I B, Treagust, F D, Won, M, and Chandrasegaran, L A 2016 *International Journal of Environmental & Science Education* **11** pp 9-27
[11] Tumay, H 2016 *Science and Education* **25** pp 21–46
[12] Pan, H, and Henriques, L 2015 S*chool Science and Mathematics* **115** pp 237-44
[13] Sheppard, K. 2006 *Chemistry Education Research and Practice* **7** pp 32-45
[14] Widarti, R H, Permanasari, A, and Mulyani, S 2016 *Jurnal Pendidikan IPA Indonesia* **5** pp 56-62
[15] Widarti, R H, Permanasari, A and Mulyani S 2014 *Analisis Kesulitan Mahasiswa Pada Perkuliahan Dasar-Dasar Kimia Analitik di Universitas Negeri Malang* (Malang: Seminar SNKP)
[16] Hasan, S, Bagayoko, D, and Kelley, E L 1999 *Physics Education* **34** pp 294−9.
[17] Hakim, A, Liliasari, and Kadarohman, A 2012 *International Online Journal of Educational Sciences*, **4**(3) pp 544−53
[18] Kurbanoglu, N I, and Akin, A 2010 *Australian Journal of Teacher Education* **35** pp 48−59
[19] Potgieter, M, Rogan, M J and Howie, S 2005 *African journal of research in SMT Education* **9** pp 121-34
[20] Bell, T, Urhahne, D, Schanze S and Rolf 2010 *International Journal of Science Education* **32** pp 349-77
[21] Rachmawati, N and Rusmini 2012 *Unesa journal of chemical education* **1** pp 34-39
[22] Linenberger, J K and Bretz, L S 2012 *Chemical Education Research &Practice* **1** pp 172-8