USEJ 8 (2) (2019)

Unnes Science Education Journal

http://journal.unnes.ac.id/sju/index.php/usej

INVESTIGATION OF PRESERVICE TEACHERS' CONCEPTUAL UNDERSTANDING IN STOICHIOMETRY USING MODIFIED CERTAINTY OF RESPONSE INDEX (CRI)

Siti Chanifah [1,✉], Mulyatun[2], Ulya Lathifa[3]

Chemistry Education Department of UIN Walisongo, Semarang, Indonesia

Article Info

Received February 2019
Accepted May 2019
Published July 2019

Keywords:
Conceptual Understanding, Preservice Teacher, Stoichiometry, Modified CRI.

Abstract

Conceptual understanding is very important for preservice teacher to master it. Stoichiometry is one of the basic concept in chemistry which applied to almost concepts. This study aims to determine the percentage of students who understand the concept, not understand the concept, and having misconceptions in stoichiometry. Furthermore, this research purposes to identify the type of misconceptions. To investigate students' conceptual understanding, we use modified CRI technique (diagnostic test with multiple choice and open reason with scale of confidence level) and interview. The results shows that the average percentage of students who understood the concept is 53.96%, having misconception is 16.20%, and did not understand the concept is 29.83%. There are 19 types of misconceptions. The causes of misconceptions include deficiency impediment, ontological impediment, and fragmentation impediment.

p-ISSN 2252-6617
e-ISSN 2252-6232

✉ Correspondence author:
Siti Chanifah
Chemistry Education Department in State Islamic University Walisongo Semarang
Jl. Prof. Hamka Kampus II Lt. 2
Telp. (024) 76433366 Semarang 50185
E-mail: sitichanifah77@gmail.com

INTRODUCTION

Chemistry is a branch of science that contains the nature of matter, material structure, material change, laws, and principles that describe the material change, as well as the concepts and theories that interpret material change (Slaubagh & Parsons 1972 as cited in Indrayani 2013). Kean & Middlecamp (1985) states that one of the characteristics of the chemistry concept is abstract, such as atomic structure, chemical bonds, and acid-base. Abstract concepts, the complexity of calculations, languages that are rarely used in daily life, and differences in representational levels (macroscopic, microscopic, and symbolic) used by chemists in explaining chemical phenomena are common reasons that make chemistry is hard to understand (Gabel & Bunce 1994 as cited in Indrayani 2013).

In Indonesia, students study chemistry since they are in Junior High School. They are introduced with the basic concept, and it has been strengthening when in senior high school. Their concept of chemistry will be more complicated when they are in college. The stratified material is expected to make students have a deep understanding of the concept, especially for a preservice teacher. Teachers are the central agents of education and strongly influence students about their understanding of the concept(Sudjana, 1989). On the other hand, McDermott (1990) stated that the quality of the learning process is highly dependent on quality in preparing preservice teachers.

Conceptual understanding of the basics of chemistry is fundamental for the preservice teacher to master it. It can help them in understanding the advance or applied material and constructing scientific knowledge. A qualified skill of material can demonstrate a concrete manifestation that a teacher is a group of exemplary people (Uno, 2008).

Based on 60 responses from questionnaires given to the preservice teacher of the Chemistry Education department in UIN Walisongo, it can be seen that most of them still difficult / not to understand in topics like chemical equilibrium, acid-base, hydrolysis, buffer, and K_{sp}. This is indicated by the high percentage of students who consider the problematic material, which is equal to 46.67%. Furthermore, 35% of preservice teachers assume that the law of basic chemistry, stoichiometry, and concentration units is a problematic concept. Few of them assume that redox and electrochemical material are difficult/ not understood yet (11.67%) and reaction rate (6.67%). The complexity of the concept and the calculations involved are the reasons why the material is considered severe.

Stoichiometry is the basic material of some concepts like chemical equilibrium (Muti'ah, 2012), acid-base, buffer solution (Siska et al., 2013), hydrolysis, and K_{sp}. Siska et al. (2013) state that mastering basic concepts is very important to be possessed by learners before studying the next material. One of the reasons that faced by the student to make learning chemistry difficult is an immature prerequisite concept. Nakhleh (1992) states that many learners at all levels of study are unsuccessful in studying chemistry because the majority of them do not build conceptual understanding well from the beginning.

The problematic assumptions of these materials are in line with the research conducted by Haryani et al. (2014) against chemistry teachers, preservice teachers, and students. Teachers and preservice teachers said that the most challenging material to understand is stoichiometry, colligative of the solution, atomic structure, elements, redox, and electrochemistry. Students assume that chemistry is difficult because of abstract material and contains many calculations and memorization.

In chemistry, conceptual understanding involves the ability to represent and understanding chemical problems into macroscopic, microscopic, and symbolic representations (Bowen & Bunce, 1997). These triple levels often create a difficult impression in studying chemistry and often causing misunderstanding (misconception). For preparing competent preservice teachers, the identification of conceptual understanding is very necessary. It aims to prevent the dissemination of misconceptions from preservice teachers to their students.

Conceptual understanding can be identified by various methods, including diagnostic tests (Astuti et al., 2016), open-ended test (Huddle & Pillay, 1996), multiple-choice tests (Agung & Schwartz, 2007), CRI (Hasan et al., 1999), and modified CRI (Hakim et al., 2012). The Certainty of Response Index (CRI) technique can be used to distinguish between students who understand concepts, do not know concepts, and having misconceptions. This technique uses multiple-choice test questions along with a Confidence Response Index (CRI). A low CRI score (<2.5) indicates the repetition of the answer, whereas a high CRI score (> 2.5) indicates that respondents have a high degree of confidence in their answers. The high level of confidence with correct answers shows that respondents have a scientific concept. Conversely, if the high confidence level and the respondents' answers are wrong, then it can be the indicator of misconceptions (Hasan et al., 1999).

The advantages of CRI techniques are simple and can be used for various levels of education (high school to college), while the weakness is the accuracy of results based on the honesty of respondents in giving CRI scale for each answer (Mahardika, 2014 as cited in Muksin et al., 2014). The study of misconceptions continues and has been developed by other researchers. Hakim et al. (2012) have successfully developed the CRI technique into a modified CRI technique, which is a multiple-choice with open reason and CRI.

Modified CRI techniques are considered appropriate to identify misconceptions for the student in Indonesia. The characteristic of students who feels less confident about their answer makes it challenging to analyze. In CRI techniques, students who understand the concept well but they are not sure to their answer can be classified into learners who do not understand the concept or just guessing the answer. Therefore, giving an open reason for each chosen answer to a CRI technique, referred to as a modified CRI technique, is considered a solution to this problem. By using modified CRI techniques, when their answer is correct, and the reason given is also true but feel unsure with it, students can be categorized to understand the concepts (Hakim et al., 2012).

Based on the descriptions mentioned above, research related to the conceptual understanding of preservice teachers in the chemistry education department by using a modified CRI technique needs to be done, especially on the material that is difficult, like stoichiometry. Therefore, the researcher is interested in researching investigating preservice teacher's conceptual understanding in stoichiometry using a modified CRI technique.

METHODS

This conducting research is descriptive research that aims to determine the percentage of students who understand the concept, do not understand the concept, and to have a misconception in stoichiometry and to know the kind of misconceptions. The sample selected using a purposive sampling technique. The sample in this research is 47 preservice teachers of the Chemistry Education department who follow Comprehensive Chemistry School classes in PK-6A class of academic year 2016/2017. The level of conceptual understanding was identified using modified CRI techniques and interviews.

The instrument test used multiple-choice with open reason and along with 0-5 CRI scale. It was validated by two expert chemistry lecturers of UIN Walisongo Semarang. From the 25 items tested, 13 questions are valid were obtained with a high level of reliability (0.807). Based on the answers, reasons, and scale of CRI given by respondents, it can be seen the kinds of conceptual understanding of students. Table 1 shows the criteria for conceptual understanding.

Table 1. Term of CRI modified for each answer Given (Hakim et al., 2012)

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

The interview was conducted after the written test. The purpose is to dig deeper conceptual understanding. Interviews were conducted to 9 of respondents with different levels of test scores, which are high, medium, and low level. It was assumed that among them, the potential to be having misconceptions (Lathifa et al., 2012).

RESULTS AND DISCUSSION

Based on the test results, the level of understanding can be grouped into 3. Namely, students understand the concept, misconception and do not understand the concept. The percentage of understanding of them can be seen in Figure 1.

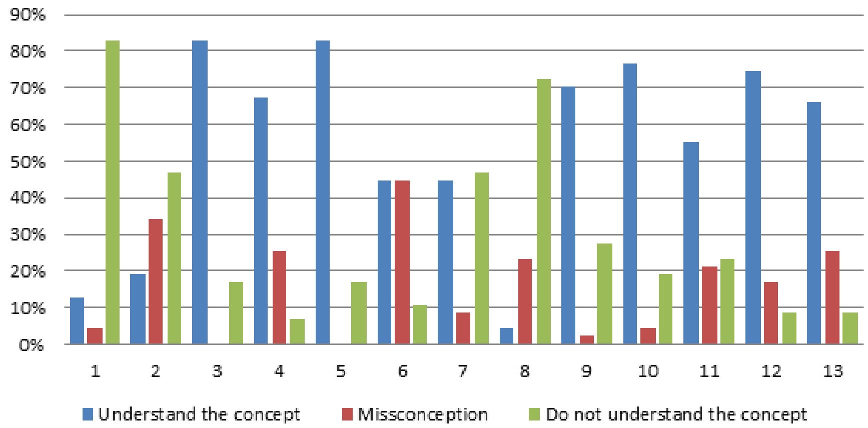

Figure 1. The Percentage of Students' Conceptual Understanding in Stoichiometry

Based on Figure 1, it can be seen that the percentage of students who understand the concept is higher than the students who had misconceptions and do not understand the concept. Based on the calculation, it is known that the average percentage of students who understand the concept is 53.96%, the misconception is 16.20%, and did not understand the concept is 29.83%

That results indicate that some students have successfully constructed the concept of stoichiometry well. That is supported by the average value of the level CRI that also high, which is 3.25. This shows that the student has a tendency to confident with their answer. Besides that, it also found misconceptions in most of the tested questions. Based on the results of the tests and interviews, it was found 19 types of misconceptions.

Table 2. Type of student misconception in stoichiometry

Subtopic	No	Type of Misconception	%
Atomic mass unit	1	1 atom = 1 amu	2,13 %
	2	1 amu = 6.02 x 10^{23} atom	2.13 %
The average atomic mass	3	The abundance of isotopes is the mass of the isotope atom divided by the atomic mass of the isotopes multiplied by 100%	21.28 %
	4	The average atomic mass is the number of multiplications between the isotope's abundance and the mass of the isotope divided by the total mass of the isotope atom	12.77 %
Conversion of mol-number of particles	5	Not paying attention to the equation of the reaction in completing the calculation	6.38 %
	6	The equation of the ethane combustion reaction is $2C_2H_6 + O_2 \rightarrow 2C_2H_4 + 2H_2O$	2.13 %
Conversion of mol-number of particles	7	The ratio of the mole to the coefficient of each compound is equal	12.77 %
	8	Calculation of the mole of the compound by dividing the molar mass of the compound by mass (in grams)	4.26 %

Subtopic	No	Type of Misconception	%
Conversion of mole-volume	9	Comparison of moles per compound is equal	8.51 %
	10	Respondents not able to understand the context in question	36.17 %
Percent compound composition	11	Percent compound composition is the relative atomic mass of 1 atom N divided by the relative molecular weight of the compound	8.51 %
The hydrate compound	12	The mass of AgCl is considered a mass of $CoCl_2$	2.13 %
	13	The relative molecular mass of $CoCl_2.xH_2O$ is equal to the mass of hydrate compound	21.27 %
The molecular formula of the compound	14	The molecular formula of the compound is the result of simplification of the mole ratio of CO_2 with a mole of H_2O	2.13 %
Number of reactants and products	15	Comparison of coefficients equaled by mass ratio	4.26 %
	16	Comparison of a mole of the compound does not match the coefficient value	17.02 %
Reagents and reaction compounds	17	Mole calculations are mass (in grams) multiplied by the relative molecular mass	4.26 %
	18	The limit reagent is residual in the reaction	34.04 %
	19	The mole ratio of each compound is considered equal	4.26 %

The highest percentage of misconception is found in mol - volume subconcept (44.68%) and the average atomic mass (34.04%). The highest percentage of the group of students who do not understand the concept is in the concept of an atomic mass unit (82.97%) and crystal water compounds (72.34%). In the sub-concept of mol-volume, misconceptions occur because students ignore the concept and focus only on numbers and mathematical formulas without understanding the actual context being asked. That problem also found in the research that conducting by Muchtar & Harizal (2012). That can be seen in the following student's answer.

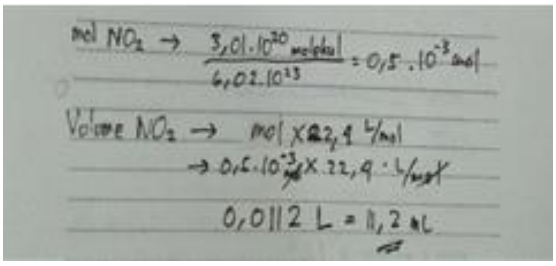

Figure 2. Student Misconceptions on the Sub-Concept of Mol-Volume

That fact is supported by interviews conducted by researchers (P) with respondents (R).

Q: "There does not seem to be a clue to the determination of the number of moles of NO_2. How can you determine the number of moles of NO_2 compounds? "

R: "There, Sist. This (the student shows the sentence about "Watched 3.01 x 10^{20} molecules of nitrogen gas with oxygen gas ...")."

In the concept of the average atomic mass, misconception occurs because students have ontological impediment. It is in line with the research conducting by Taber (2002). Ontological impediment isa condition that indicates a lack of synchronization between respondent's understanding and the given problem. Respondent considers that the average atomic mass is the number of multiplications between the isotopic abundance and the mass of the isotope divided by the sum of the atomic isotope mass. This can be seen in the completion of some of the following students.

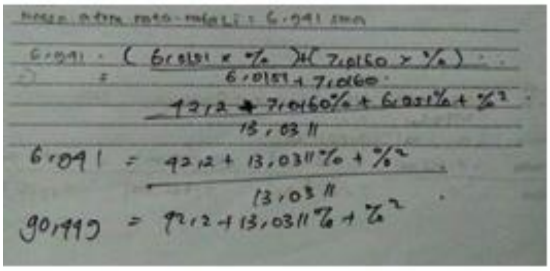

Figure 3. Student Misconceptions on The Concept of Average Atomic Mass

The answer in Figure 3 is contrary to the actual concept, which the atomic mass of an element is the sum of the mass of each isotope multiplied by its abundance (Effendy, 2016: 24). The abundance of isotopes of an element present in nature when summed will produce a whole number (100%).

In the concept of atomic mass units, students have deficiency impediments as said by Taber (2002) in his research. It is an obstacle caused by misunderstanding or lack of knowledge. Students assume that one sma is equal to 1 atom. Another opinion states that one sma equals 6.02 x 10^{23} (Avogadro number).

In the concept of crystal water compounds, a misconception occurs due to fragmentation impediment. It is in line with Taber (2002) research. It is the disconnection of understanding possessed by ignoring other concepts involved. Respondents tend to ignore the concept of the mole ratio of the reaction.

CONCLUSION

Based on the result and discussions, it can be concluded that the average percentage of a preservice teacher who understood the concept in stoichiometry is 53.96%, having misconception is 16.20% and did not understand the concept is 29.83%. There are 19 types of misconceptions. The causes of misconceptions include deficiency impediment, ontological impediment, and fragmentation impediment.

ACKNOWLEDGMENT

Author would like to thank (1) Mulyatun, M.Si and Ulya Lathifa, M.Pd have provided guidance to the researcher, (2) Anita Fibonacci, M.Pd as a lecturer of Comprehensive Chemistry School subjects who have allow researchers to conduct research in the PK-6A class, and (3) all those who have assisted the researcher in completing this research.

REFERENCES

Agung, S., & Schwartz, M. S. (2007). Students' understanding of conservation of matter, stoichiometry and balancing equations in Indonesia. *International Journal of Science Education*, *29*(13), 1679-1702.

Astuti, F., Redjeki, T., & Nurhayati, N. D. (2016). Identifikasi Miskonsepsi dan Penyebabnya Pada Siswa Kelas XI MIA SMA Negeri 1 Sukoharjo Tahun Pelajaran 2015/2016 pada Materi Pokok Stoikiometri. *Jurnal Pendidikan Kimia*, *5*(2), 10-17. Bowen, C. W. & Bunce, D. M. (1997). Testing for Conceptual Understanding in General Chemistry. *The Chemical Educator*. 2 (2), 1-17.

Effendy. (2016). *Ilmu Kimia untuk Siswa SMA dan MA Kelas X*. Malang: Indonesian Academic Publishing.

Hakim, A., & Kadarohman, A. (2012). Student Concept Understanding of Natural Products Chemistry in Primary and Secondary Metabolites Using the Data Collecting Technique of Modified CRI. *International Online Journal of Educational Sciences*, *4*(3). Haryani, S., Prasetya, A. T., & Saptarini. (2014). Identifikasi Materi Kimia Sulit Menurut Pandangan Guru dan Calon Guru Kimia. (*Makalah Pendamping SN-KPK VI*). 43-52.

Hasan, S., Bagayoko, D., & Kelley, E. L. (1999). Misconceptions and the certainty of response index (CRI). *Physics education*, *34*(5), 294.

Huddle, P. A., & Pillay, A. E. (1996). An in- depth study of misconceptions in stoichiometry and chemical equilibrium at a South African university. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *33*(1), 65-77.

Indrayani, P. (2012). Analisis Pemahaman Makroskopik, Mikroskopik dan Simbolik Titrasi Asam-Basa Siswa Kelas XI IPA SMA serta Upaya Perbaikannya Dengan Pendekatan Mikroskopik.(Tesis). *DISERTASI dan TESIS Program Pascasarjana UM*.

Kean, E. & Middlecamp, C. (1985). *Panduan Belajar Kimia Dasar*. Jakarta: Gramedia.

Lathifa, U., Ibnu, S., & Budiasih, E. (2015). Identifikasi Kesalahan Konsep Larutan Asam-Basa dengan Menggunakan Teknik Certainty of Response Index (CRI) Termodifikasi. In *Seminar Nasional Pendidikan Sains UKSW* (pp. 242-249).

Mahardika, R. (2014). Identifikasi Miskonsepsi Siswa Menggunakan *Certainty of Response Index* (CRI) dan Wawancara Diagnosis pada Konsep Sel. *Skripsi* *tidak diterbitkan*. Jakarta: UIN Syarif Hidayatullah.

McDermott, L. C. (1990). A perspective on teacher preparation in physics and other sciences: The need for special science courses for teachers. *American Journal of physics*, *58*(8), 734-742.

Muchtar, Z. (2012). Analyzing of students'misconceptions on acid-base chemistry at senior high schools in Medan. *Journal of Education and Practice*, *3*(15), 65-74.

Muksin, M., Lukum, A., & Mohamad, E. (2015). *Identifikasi Miskonsepsi Siswa Pada Materi Asam Basa Menggunakan Certainty Of Response Index (CRI) Pada Siswa Kelas XI IPA 2 Di SMA Negeri 1 Bonepantai* (Doctoral dissertation, ung). Muti'ah. (2012). Analisis Miskonsepsi Mahasiswa pada Empat Konsep Esensial Kesetimbangan Kimia. *Jurnal Pijar MIPA*. 7 (1), 1-42.

Nakhleh, M. B. (1992). Why some students don't learn chemistry: Chemical misconceptions. *Journal of chemical education*, *69*(3), 191.

Siska, A., Amran, E. Y., & Herdini. (2013). Pemberian Materi Prasyarat Untuk Meningkatkan Prestasi Belajar Siswa.

pada Pokok Bahasan Larutan Penyangga di Kelas XI SMA Negeri 1 Pekanbaru. Program Studi Pendidikan Kimia FKIP Universitas Riau.

Sudjana, N. (1989). *Dasar-dasar Proses Belajar Mengajar*. Bandung: CV Sinar Baru.

Taber, K. S. (2002). *Chemical Misconceptions – Prevention, Diagnosis and Cure: Theoritical background (Vol. 1)*. London: Royal Society of Chemistry.

Uno, B. H. (2008). *Profesi Kependidikan: Problema, Solusi, dan Reformasi Pendidikan di Indonesia*. Jakarta: PT Bumi Aksara.