Pre-services science teachers’ conceptual understanding level on several electricity concepts

D E Saputro1*, S Sarwanto1, S Sukarmin1 and D Ratnasari2

1 Program Magister Pendidikan Fisika, Universitas Sebelas Maret, Jl. Ir. Sutami 36A Kentingan, Jebres, Surakarta 57126, Indonesia
2 Program Magister Pendidikan Sains, Universitas Sebelas Maret, Jl. Ir. Sutami 36A Kentingan, Jebres, Surakarta 57126, Indonesia

*didik_eko@student.uns.ac.id

Abstract. This research is aimed to analyze pre-services science teachers’ conceptual understanding level on several electricity concepts. This research belongs to descriptive research. The subjects of the research were 88 pre-services science teachers of Sebelas Maret University from physic and science education in academic year of 2017/2018. The instrument of the research was multiple choices with open-ended responses. Based on the result of answer analysis, it showed that most of pre-services science teachers had partial understanding with misconception on subtopic of characteristic of electrical current in series and parallel circuit. Meanwhile, the lowest level of conceptual understanding was on subtopic effect of charging and discharging capacitor to the loads. Due to the number of pre-services science teachers whose misconception on several electricity concepts, it is expected that teachers are able to develop the appropriate learning method because electricity concept is closely related to the daily life.

1. Introduction

Conceptual understanding is a key of concept implementation that has been admitted as one of the main purposes in science education [1]. Conceptual understanding can be defined diversely. It is commonly defined as the learning with understanding [2]. Therefore, conceptual understanding is contrasted with the learning of declarative knowledge, which the students only memorize the relation among things, events and processes [3]. Conceptual understanding covers relation memories, so it needs a skill to implement the previous learning on the unexpected previous experience [4]. Conceptual understanding includes association, comparison, assimilation, and reorganization of new knowledge and existing knowledge and transfers it to solve the new problems. Conceptual understanding is based on the reorganization of the existing knowledge as stated by the previous researchers on their theory of cognitive learning [5,6,7,8]. Therefore, learning with conceptual understanding can be defined as an Ausubelian meaningful learning that focuses on more than memorizing activity.

A good physic concept understanding is able to get students to express the new concept with other ways in various representations. A good conceptual understanding also brings students to have various skills such as memorizing, explaining, finding facts, stating examples, generalizing, implementing, analogizing, and stating the new concept with other ways [9].
One of the most difficult concepts in physics is electrical concept. Electricity is invisible. However, it is wherever in our life [10]. There are many models and analogies in electricity used. Yet, nothing can explain on each aspect [11]. Electricity is abstract, and many students have wrong idea on electrical circuit [10]. Electricity concept is one of the basic important concepts in physics. It must be taught in every level of education. In elementary school, students get an experience on simple electricity circuit. On the next level, electricity is taught systematically and becomes a significant theme [12]. Many students find conceptual difficulty in analyzing simple electricity circuit. The difficulties are on disability to implement formal concept related to current, voltage, and resistance. As a result, students have less conceptual model and cannot have any reason on the characteristic of electricity circuit qualitatively [13].

One of the challenges in assessing students’ conceptual understanding is the scarcity of tools and valid assessment method [14,15,16,17,18]. Historically, teachers have tried to measure students’ conceptual understanding in science through assessment of multiple choices. It uses one correct answer choice and two or more wrong choices [19,20]. However, this kind of assessment has been criticized because it has certain limits in helping teachers to access and to understand the students’ logic on their answer [21,22,23]. Therefore, it needs alternative instrument that can recognize students’ conceptual understanding through multiple choices with open-ended responses.

Based on the elaboration above, the researcher wants to know the level of conceptual understanding of pre-service science teacher on several electricity concepts in Sebelas Maret University. The analysis of conceptual understanding used multiple choices instrument with open-ended responses.

2. Method
This research belonged to descriptive research. It was aimed to analyze pre-services science teachers’ conceptual understanding level on several electricity concepts. The subjects of the research were pre-services science teachers of Sebelas Maret University from physics and science education in academic year of 2017/2018. There were 48 pre-services science teachers of physics education and 40 pre-services science teachers of science education. Data of the research was obtained from the test result using multiple choice instruments with open-ended responses. It was used to analyze level of conceptual understanding to the pre-services science teachers. The instrument consisted of 24 questions of 7 subtopics as figured out at the table 1.

| No | Sub topic                                                                 | Number of question |
|----|---------------------------------------------------------------------------|--------------------|
| 1  | Characteristics of electrical current in series and parallel circuit       | 1, 2, 4, 6, 8      |
| 2  | Characteristics of voltage in series and parallel circuit                 | 3, 5, 7            |
| 3  | Effect of capacitor condition on closed circuit                          | 9, 10, 11, 12      |
| 4  | Value of capacitor capacitance                                           | 13, 14, 15         |
| 5  | Effect of charging and discharging capacitor to the loads                | 16, 17, 18         |
| 6  | Quantity in capacitor series circuit                                     | 19, 20, 21         |
| 7  | Quantity in capacitor parallel circuit                                   | 22, 23, 24         |

3. Result and discussion
The test result was analyzed using assessment guidance that has been arranged. The assessment guidance in these questions is shown in table 2 [24].

Test of multiple choices with open-ended responses can help teachers to analyze and classify the answers and the reasons. Therefore, it can be seen that group of students understand the concept and find problems in learning concept [25]. The advantage of this test is the students can directly choose the suitable answers and express the concept as the reasons to choose the answer. The weakness of this test is that the students give correct reasons of their version. However, teachers will find difficulty in correcting the test result.
Table 2. Assessment guidance of multiple choice instruments with open-ended responses [24].

| No | Assessment aspect                                      | Score | Level of conceptual understanding                      |
|----|--------------------------------------------------------|-------|--------------------------------------------------------|
| 1  | Do not choose any answer and reason, or wrong answer-wrong reason | 0     | No understanding (NU)                                  |
| 2  | Wrong answer-correct reason                            | 1     | Partial understanding with misconception (M)           |
| 3  | Correct answer-wrong reason                            | 2     | Partial understanding with misconception (M)           |
| 4  | Correct answer-correct reason                          | 3     | Sound understanding (SU)                               |

Table 1 is used as the answer assessment guidance of pre-services science teachers. Data consisted of the answer of pre-services science teachers. Then, it was analyzed and counted its percentage of achievement on each sub topic. The graphic of pre-services science teachers’ conceptual understanding level on several electricity concepts is shown in figure 1. The amount of percentage was obtained from the answer analysis and the reason stated by pre-services science teachers. The answers were analyzed based on the assessment guidance at table 2 to determine level of conceptual understanding.

Figure 1. pre-services science teachers’ conceptual understanding level on several electricity concepts.

Based on figure 1, percentage of No Understanding (NU) is mostly found on subtopic 5 (The effect of charging and discharging capacitor to the loads). Percentage of Partial Understanding with misconception (M) is mostly on subtopic of the characteristics of electrical current in series and parallel circuit. The lowest percentage of Sound Understanding (SU) is on subtopic 5. The subtopics that show the most misconception need more attention because it will effect to other electrical concepts.

Subtopic 5 has highest percentage of NU and lowest percentage of SU. This subtopic contains the effect of charging and discharging capacitor to the loads. The subtopic consists of 3 questions sourced by same questions. The question in this subtopic is that this circuit consists of two identical lamps (L1 and L2), a capacitor, an electric switch and a battery which the value of resistance is neglected.

Figure 2. Electricity circuit on subtopic 5.

Based on the circuit in figure 2, pre-services science teachers were asked to determine which lamp would light up brightly when the electric switch was closed, which lamp would light up brightly when the electric switch was closed and capacitor was fully charged, which lamp would light up brightly...
when the electric switch was closed after capacitor was fully charged. Then, battery was pulled off and it was re-connected with the wire. In this subtopic, many pre-services science teachers didn’t understand the effect of charging and discharging capacitor to the loads. The answers can be seen in figure 3.

![Figure 3](image)

**Figure 3.** The example of pre-services science teachers’ answer on subtopic 5.

Based on figure 3, pre-services science teachers considered that the current streamed from positive pole to negative pole. As a result, the lamp which is close to positive pole would light up brighter because there was no resistance or loads. It was same with the previous research. It showed that metal sheet which was connected to positive pole would firstly charge. Meanwhile, another capacitor could not be charge before the first one was full. Consequently, there would not be a current in another circuit and it was only the first lamp that would light up brightly [26].

Another subtopic that needs special attention was subtopic of the characteristics of electrical current in series and parallel circuit. It had the highest misconception percentage. In this subtopic, it consisted of 5 questions. One of the questions in this subtopic was if the lamp was identical, how was the correct series of electric current on point A, B, C, D, E, F. The picture of electric series in this question can be seen in figure 4.

![Figure 4](image)

**Figure 4.** Electricity circuit on subtopic 1.

Based on the electric series above, pre-services science teachers were asked to determine the quantity of electric current received by each branch point. To finish the question, they should understand the characteristic of series and parallel circuit and could implement law of Khirhoff 1. Although this subtopic had been learned since junior high school, the teachers still found misconception. The example of pre-services science teachers’ answer can be seen in figure 5.

![Figure 5](image)

**Figure 5.** The example of pre-services science teachers’ answer on subtopic 1.

Based on the figure 5, the teachers still thought that if the location of branch point was further from current or battery source, the electric current would also be smaller. This misconception was also revealed by the previous researcher. Students considered that the biggest electric current was on the component which was close to the current source [27]. The example of pre-services science teachers’ answer can be seen in figure 6.
Figure 6. The example of pre-services science teachers’ answer on subtopic 1.

Based on figure 6, the teachers stated that lamp consumed and absorbed electric current. So, total electric current that streamed on the circuit would be decreased. The teachers forgot the characteristic of series and parallel circuit that had been learned before. The same misconception was also revealed by the previous researcher. Students still considered that electric current was consumed by electric component [28].

The low of students’ conceptual understanding was caused by learning method and assessment process. It tended to learn about the mathematical equation than concept understanding [29]. To solve the problem, it needed integrity between mathematical skill and conceptual understanding to minimize misconception [30].

4. Conclusion

Based on the analysis of answer result, it can be concluded that most of pre-services science teachers had partial understanding with misconception on subtopic characteristics of electrical current in series and parallel circuit. The lowest level of conceptual understanding was on subtopic effect of charging and discharging capacitor to the loads. Due to the number of pre-services science teachers who found misconception on several electricity concepts, it is expected that teachers are able to develop the appropriate learning method because electricity concept is closely related to the daily life.

Acknowledgements

The writer would like to say his gratitude to his parents for their continuous prayers. For Ms. Dewi Ratnasari as a partner in this research and for all who have given their help to finish this article.

References

[1] Barbosa P and Alexander L 2004 Science inquiry in the CORI framework In J T Guthrie, A Wigfield, and K C Perencevich (Eds.), Motivating Reading Comprehension: Concept-Oriented Reading Instruction, pp 113-141 (Mahwah, NJ: Erlbaum)
[2] Driver R, Asoko H, Leach J, Scott P and Mortimer E 1994 Educ. Res. 23 5-12
[3] Darmofal D L, Soderholm D H and Brodeur D R 2002 FIE 32nd Annual
[4] Smith P L and Ragan T J 1999 Instructional design (New York: Wiley-Interscience)
[5] Duit R 1999 Conceptual change approaches in science education. In W Schnitz, S Vosniadou, and M Carretero (Eds.), New perspectives on conceptual change (Amsterdam, NL: Pergamon) pp 263-282
[6] Piaget J 1951 The child's conception of the world (Lanham: Rowman & Littlefield)
[7] Posner G J, Strike K A, Hewson P W and Gertzog W A 1982 Scie. Educ. 66 211-227
[8] Tobin K, Tippins D, and Gallard A 1994 Research on instructional strategies for teaching science In D L Gabel (Ed.), Handbook of research on science teaching and learning (New York: Macmillan) pp 45–93
[9] Eggen P, and Kauchak D 2012 Strategi dan Model Pembelajaran (edisi keenam) (Jakarta Barat: PT Indeks)
[10] Kollöffel B and De Jong T 2013 JEE 102 375–393
[11] Frederiksen J R, White B Y and Gutwill J 1999 JRST 36 806-836
[12] Toulia E H, Talibia M, Radida M 2015 Procedia Soc. Behav. Sci. 197 278 – 280
[13] McDermott L C and Shaffer P S 1992 Am. J. Phys. 60 994-1003
[14] Briggs D, Alonzo A, Schwab C and Wilson M 2006 Educ. Assess. 11 33-64
[15] Caleon I and Subramaniam R 2010 IJSE 32 939-961
[16] Chu H, Treagust D F and Chandrasegaran A 2009 Res. Sci. Technol. Educ. 27 253-265
[17] Hudson R D and Treagust D F 2013 Res. Sci. Technol. Educ. 31 49-65
[18] Kirbulut Z D and Geban O 2014 EURASIA J. Math. Sci. Tech. Ed. 10 509-521
[19] Linn R L and Gronlund N E 2000 Measurement and assessment in teaching (8th ed.). Upper Saddle River (NJ: Prentice Hall, Inc)
[20] Treagust D F 1986 Res. Sci. Educ. 16 199-207
[21] Pesman H and Eryilmaz A 2010 J. Educ. Res. 103 208-222
[22] Tan K C D, Goh N K, Chia L S and Treagust D F 2002 J. Res. Sci. Teach. 39 283-301
[23] Voska K W and Heikkinen H W 2000 J. Res. Sci. Teach. 37 160-176
[24] Sukarmin, Suparmi and Ratnasari D 2017 ASSEHR 158 179-189
[25] Kwen, Boo Hong 2005 Proc. Int. Conf. Educational Research Conference, Singapore
[26] Bilal E and Erol M 2009 Lat. Am. J. Phys. Educ. 3 193-201
[27] Wainwright C L 2007 Toward Learning and understanding electricity: Challenging persistent misconceptions (Pacific University: Science Education)
[28] Küçüközer H and Kocekülah S 2007 TUSED 4 101-115
[29] Ratnasari D, S Sukarmin, and S Suparmi 2017 IOP Conf. Series: Journal of Physics: Conf. Series 909 012054
[30] Handhika J, Cari, Suparmi and Sunarno W 2015b AIP Conf. Proc. 1-5