The identification of the 11th grade students’ prior knowledge of electricity concepts

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Abstract. According to constructivism, prior knowledge plays an important role in building students' scientific knowledge. Prior knowledge influences how students assimilate and accommodate new information. Prior knowledge affects how students perceive, organize, and create new information relationships. Therefore, in order to improve meaningful learning, students’ prior knowledge needs to be identified. The purpose of this study was to identify the 11th grade-students’ prior knowledge of electricity concepts. Students’ prior knowledge was measured using a Three-Tier Electricity Multiple Choice Test, which consisted of 20 items. This test was given to seventy-five 11th grade students, who were 16-17 years of age. The data were analyzed descriptively. The results showed that students’ prior knowledge about electricity concepts was very diverse; only 22.40% of the students had a scientific concept; 36.73% of students experienced misconception; 31.20% of students do not know the concept, and 9.67% of students experience the error. Students’ misconceptions about electricity concepts that were found in this study are in mutual accord with the literature of misconception. The implication of the research results for teaching about electricity is that appropriate conceptual change strategies are needed.

1. Introduction

Studies showed that students come to formal instruction with their prior knowledge of electricity that they have constructed [1] [2] [3] [4]. There are some terms used for prior knowledge, such as preconception [5]; children science [6][1]; alternative conception [7] and misconception [8].

Some prior knowledge often takes the form of misconception [9] [5]. Misconception influences the way students learn about new knowledge and plays an important role in learning [10]. Misconceptions that students bring conflict with scientific explanation [11]. Facts show that misconception is the most significant factor that contributes negatively to students’ academic success [12]. Wrong prior knowledge can cause difficulties in learning [13].

Electricity is an important topic in physics. In addition to being related to the materials in physics itself, electricity also plays an important role in other sciences such as chemistry and biology. To teach electricity meaningfully the teacher has to identify students’ prior knowledge about electricity. This study was conducted to answer the following questions: what does the students’ prior knowledge of electricity look like?

2. Theoretical Framework

Prior knowledge define as an individual’s entire knowledge that is (1) dynamic, (2) that existed before instruction, (3) is structured, (4) can exist in various forms (declarative, procedural, and conditional knowledge ), (5) is explicit and implicit , and (6) contains conceptual and metacognitive
knowledge components [14]. Students’ prior knowledge can be as an alternative conception or scientific conceptions possessed by the students [15].

According to constructivism, prior knowledge plays an important role in developing students’ knowledge. In constructivist literature, in learning physics, there are three roles of prior knowledge i.e.: the knowledge-as-theory, the knowledge-as-elements and the knowledge-as-system accounts [16]. Constructivism views learning as the construction and acceptance of new ideas or reconstruction of the existing ideas [6]. Prior knowledge influences how students accommodate and assimilate new information. Prior knowledge influences how students perceive, organize information and make new information connections [17].

In relation to prior knowledge in physic instruction, prior knowledge is one of the factors that influence students’ learning [18]. Prior knowledge has a positive effect on students’ learning achievement [19] [20]. However, on the other hand, the students’ prior knowledge can also become the hindrance to learn because some prior knowledge may contradict with information that will be learned [21].

Prior knowledge or alternative conception is acquired by students through interactions with the environment through experiences. Every student has the different experience, hence their mental structure about a concept that they acquire is also different, some of which can cheat prior thinking [22]. The Alternative conceptions that students develop can hinder their conceptual understanding [23]. The explanation above shows that it is important for science teachers to know their students’ prior knowledge before teaching new concepts. Students’ prior knowledge can be used as a catalyst for learning and foster to understanding scientific concepts.

3. Method

3.1 Subject of Study
This study was aimed at identifying the 11th grade students’ prior knowledge of electricity concepts. This study was conducted at SMA Negeri 1 Singaraja, one of the favorite schools in Singaraja City. The students of the school generally also originated from the best graduates of the junior high school in Singaraja. They are the students who were accepted through national junior high school examination result and those who were accepted through academic potential test and achievement. There were 75 students aged 15-16 years old who participated in this study. Before the test was given to them they had not studied electricity material from senior high school curriculum, although they had learned electricity at the lower education levels before, at the elementary school and at junior high school.

3.2 Instrument
The instrument used to identify the students’ prior knowledge of electricity concept was Three Tier Electricity Diagnostic Test (TTEDT) which was modified from [5] [24] [25]. This test was a multiple choice test with three levels. The first level, multiple choice with answer alternatives that should be chosen by the students based on the prior knowledge that they had. The second level contained reason choices from the answers in the first level. If in [5] all reasons were provided but in this test in addition to being provided with the reasons, the students were also given the opportunity to write down their own reasons if the reasons provided do not fit with their minds. The third level contained belief choices toward the students’ options in the first level which contained two options, that is, sure and not sure. The used TTEDT had a reliability index r= 0.728.

3.3 Data Analysis
The data of the students’ prior knowledge were analyzed descriptively. The TTEDT instrument would produce three kinds of information, that is, answers to the first level multiple choice, answers to the choice of reasons to answers to the first level, and answers to belief choices in the third level. The
three types of data were then combined to make students’ prior knowledge categories. The combination looks like that in table 1.

### Table 1: Categories of the types of students’ answers

| Answer level 1 | Answer level 2 | answer level 3 | Prior knowledge category |
|----------------|----------------|----------------|--------------------------|
| True           | True           | Sure           | Scientific Knowledge (SK) |
| True           | True           | Not sure       | Lack Knowledge (LK)       |
| Wrong          | True           | Not sure       | Lack Knowledge (LK)       |
| True           | Wrong          | Not sure       | Lack Knowledge (LK)       |
| Wrong          | Wrong          | Wrong          | Lack Knowledge (LK)       |
| Wrong          | True           | Sure           | Error (E)                |
| True           | Wrong          | Sure           | Misconception (M)         |
| Wrong          | Wrong          | Sure           | Misconception (M)         |

Adapted from [26]

Based on the categoryze above, the percentages of the students who had scientific concept, lack concept, and misconception were then calculated. The students’ conceptions of electricity were described qualitatively.

### 4. Result and Discussion

Table 2 shows the frequency of students with prior knowledge on electricity concept categorized into Scientific Knowledge (SK), Misconception (M), Lack Knowledge (LK) and Error (E), for each test item.

### Table 2: Frequency and percentagge of students with prior knowledge categorized into SK, M, LK, and E for each test item

| Physics Prior Knowledge | Item No | SK f | % | M f | % | LK f | % | E f | % |
|------------------------|---------|------|---|-----|---|------|---|-----|---|
| How to light the bulb lamp | 1       | 56   | 74.67 | 8 | 10.67 | 11 | 14.67 | 0 | 0.00 |
| The direction of electric current in a simple circuit | 2       | 26   | 34.67 | 21 | 28.00 | 19 | 25.33 | 9 | 12.00 |
| Electric current definition | 3       | 32   | 42.67 | 13 | 17.33 | 28 | 37.33 | 2 | 2.67 |
| The magnitude of electric currents in single loop circuits | 4       | 8    | 10.67 | 39 | 52.00 | 22 | 29.33 | 6 | 8.00 |
| Ohm law. | 5       | 40   | 53.33 | 11 | 14.67 | 21 | 28.00 | 3 | 4.00 |
| I-V graph | 6       | 19   | 25.33 | 25 | 33.33 | 23 | 30.67 | 8 | 10.67 |
| Determinant factors of the resistance of the conductor | 7       | 8    | 10.67 | 24 | 32.00 | 33 | 44.00 | 10 | 13.33 |
| Conductor | 8       | 26   | 34.67 | 20 | 26.67 | 25 | 33.33 | 4 | 5.33 |
| Bulb lamp in parallel | 9       | 43   | 57.33 | 14 | 18.67 | 8 | 10.67 | 10 | 13.33 |
| Total resistance of resistor parallel | 10      | 4    | 5.33 | 39 | 52.00 | 18 | 24.00 | 14 | 18.67 |
| The electric current of bulb lamp in parallel | 11      | 14   | 18.67 | 37 | 49.33 | 23 | 30.67 | 1 | 1.33 |
| The electric current of | 12      | 6    | 8.00 | 39 | 52.00 | 27 | 36.00 | 3 | 4.00 |
From table 2 it is apparent in general that out of 75 students, there was only 22.20% of them had prior knowledge which fell into scientific knowledge category on the other hand, 36.73% of the students had prior knowledge which fell into misconception category, 31.20% fell into lack concept and 9.67% into error category. This result was similar to the result of research by [27] in Cimahi, Bandung, that shows that 13.9% of the students understood the concept, 39.9% had the misconception, 44.5% lack concept, 2.19% had errors.

The highest percentage of students who had scientific knowledge was in the test item number 1, that is, how to light the bulb lamp. While the highest percentage of the students had misconception in the test item number 17 on power specification of the electrical device. The highest percentage of students who lacked concepts occurred in the test item number 15, that is, emf and the potential difference across a real battery. The highest frequency of the students who had errors occurred in how the fuse works.

There were 22 types of misconception that could be identified in this study. Some of the misconceptions were similar to the ones found in some misconception literature. The following are the types of students’ misconception on electricity identified through TTEDT.

1. Bulb lamp can only light if the metal box part is touched to the positive pole of the battery and the hidden part is connected to the negative pole of the battery, otherwise, it does not light. This misconception is also found in [24].

2. If a lamp is connected to a battery, electric current will flow from positive pole to the lamp and from negative pole to the lamp, meeting at the lamp so that the lamp lights. This misconception is similar to the one found by [3], in which the current flows to the lamp from both battery terminals with the same magnitude.

3. Electric current flows from the low potential to the high potential. A similar misconception was found by [5], that is, the direction of electric current is from negative pole toward positive pole.

4. The magnitude of electric current is the charge that flows multiplied by the duration of the flowing charge the longer the conductor is connected to the source of voltage, the greater the electric current.of electric current is the charge that flows multiplied by the duration of the
(5) Electric current at the point closer to the source of voltage is bigger than the electric current at the farther point from the source of voltage. A similar misconception is also found in [24].

(6) The closer to the positive pole of battery the greater the current. A similar misconception is also found in [3].

(7) The electricity current at the point close to the positive pole of the battery is greater than the electric current closer to the negative pole of the battery. This is similar to the students’ misconception found in [5], that is, the current in the positive pole of the battery is always bigger than the current in the negative pole of the battery. This result is also similar to the one in [3]. The electric current on the positive terminal side of the battery is always bigger than the current on the negative terminal side.

(8) The steeper the slope of curve I-V of a conductor, the smaller the electrical resistance of the conductor.

(9) There is no relation between the steepness of curve I-V of a conductor and the electrical resistance of the conductor.

(10) The magnitude of the current that flows in a conductor does not depend on the dimension of the conductor.

(11) The magnitude of the current that flows in a conductor does not depend on the dimension of the conductor.

(12) There is no relation between the conductor dimension and its conductor.

(13) The wider the area of conductor cross-section the greater the electrical resistance. This misconception is similar to the one found in [28].

(14) The students cannot determine the total electric resistance from two electrical resistances that are parallel arranged.

(15) The magnitude of the electric current that flows from the battery with electric motion force (emf) \( \varepsilon \) connected to lamp with electrical resistance greater than that connected to 2 identical lamps arranged in parallel.

(16) The magnitude of the electric current that flows from the battery with emf \( \varepsilon \) connected to a lamp with electrical resistance \( r \) smaller than that connected with an identical lamp serially arranged. This misconception is also found in [24].

(17) Electrical resistance in the battery does not have any effect on the result of measurement with a potential difference. The measured potential difference is the same as the emf of the battery.

(18) Electric resistance in battery causes the terminal potential difference is read bigger than its emf.

(19) Power produced by one battery is smaller than by two batteries parallely arranged and is smaller than two batteries serially arranged. This is also found in [24].

(20) Fuse prevents short circuit that occurs because of a very big electric resistance.

(21) It is better to make a fuse from bigger wire to make it's strong.

(22) Fuse with a big current specification is safer.

(23) To measure the strength of current and potential difference in conductor with closed circuit, ammeter and voltmeter are installed series with its conductor.

The students’ prior knowledge on electricity identified in this study shows that before learning about electricity at a certain level, the students had varied prior knowledge some of them were in the form of scientific knowledge, misconception, lack knowledge and error. These findings further reinforce the view that it is important for the teacher to identify the initial range of students’ prior knowledge before beginning the lesson. The types of prior knowledge shown are very important material for selecting teaching strategies, especially conceptual changes strategy. Learning should be done in order to reconstruct the student's prior knowledge.
5. Conclusion and Suggestion

5.1 Conclusion
The students come to a formal instruction bringing with them a variety of prior knowledge of electricity concepts. By using Three Tier Electricity Diagnostic Test, the students’ prior knowledge can be categorized into four categories, that is the scientific concept, misconception, lack knowledge, and error. The results of the study showed that 22.20% of the students had prior knowledge in the form of scientific knowledge, 36.73% of the students had misconception, 31.20% lack knowledge and 9.67% had errors. Some of the students’ misconceptions were similar to the ones in the literature on misconceptions. The types of the students’ prior knowledge identified in this study can be used as the source by the teachers to plan meaningful electricity instruction. Hence, the identification of the types of students’ prior knowledge of electricity is a necessity.

5.2 Suggestion
To physics teachers, it is suggested to identify students' prior knowledge of electricity concepts before beginning the lesson. This variety of students’ prior knowledge should be used as a reference in the development of teaching materials and conceptual change strategies to build scientific knowledge and reduce misconceptions.

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References
[1] Osborne R, Freyberg P, Bell B, Tasker R, Cosgrove M and Schollum B 1985 *Learning in Science The Implication of Children’s Science* (Auckland: Heinemann) p 5-27
[2] Maloney D P, O’Kuma T I, Hieggelke C J and Heuvelen A V 2001 *Am. J. Phys. Suppl.* 69 S12-S23
[3] Küçüközer H and Kocakülah 2007 *Journal of Turkish Science Education*. 4 101-115
[4] O'Dwyer A 2009 *AISHE. Conf.* NUI Maynooth
[5] Turgut U, Gürbüz F and Turgut G 2011 *Procedia Social and Behavioral Sciences*. 15 2011 1965–1971.
[6] Bell B F 1993 *Children’s Science, Constructivism, and Learning in Science* (Victoria Deakin University) p 12
[7] Petersson G 2002 3rd *European Sym. on Conceptual Change*, June 26-28 2002, Turku, Finland
[8] Brown D E and Clement J *Instructional Science*. 18 237-261
[9] Demerci N 2005 *The Turkish Online Journal of Educational Technology*. 4 40-48
[10] Ozmen H 2007 *Asia Pasific Education Review*. 8 413-425
[11] Broughton S H, Sinatra G M and Reynold R E 2010 *Journal Of Educational Research*. 103 407-423.
[12] Ozkan G, Selcuk G S 2013 *Asia Pasific Forum on Science Learning and Teaching*. 14 1-17
[13] Gürefe N, Yarar S H, Pazarbasi B N and Es H 2014 *International Journal of Educational Studies in Mathematics*. 1 58-68.
[14] Dochy F J R C and Alexander P A 1995 *European Journal of Psychology of Education*. X 225-242.
[15] Hewson M G and Hewson P W 2003 *Journal of Research in Science Teaching*. 40 886-898
[16] Esanu A and Hatu C 2015 *Int. Scientific Conf. eLearning and software for Education Bucharest* 25-26
[17] Svinicki M 1993-94 Essays on Teaching Excellence. Toward the Best in the Academy. 5
[18] Baser M 2006 Journal of Maltase Education Research. 4 64-79
[19] Calisir F and Gurel Z 2003 Computers in Human Behavior. 19 135–145
[20] Calisir F, Eryazici M and Lehto M R 2008 Computers in Human Behavior. 24 439-450
[21] Cordova J R, Sinarta G M, Jones S H, Taasoobshirazi G and Lombardi D 2014 Contemporary Educational Psychology. 39 164-174
[22] Akpınar M and Tan M 2011 Western Anatolia Journal of Educational Sciences. 139-144.
[23] Salame I, Sarowar S, Begum S and Krauss D 2011 Chem. Educator. 16 190–194
[24] Engelhardt P V and Beichner R J 2004 Am. J. Phys. 72 98-115
[25] Pesman H and Eryilmaz A 2010 The Journal of Educational Research. 103 208–222
[26] Kaltakçi D and Nilüfer D 2007 6th Int. Conf. of the Balkan Physical Union (American Institute of Physics) pp 499-500
[27] Ismail I I, Samsudin A, Suhensi and Kaniawati I 2015 Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains 2015: 8 -9 Juni 2015, Bandung, Indonesia.
[28] Bilal E and Erol M 2009 Lat. Am. J. Phys. Educ. 3 193-201