An investigation 10\textsuperscript{th} grade students’ misconceptions about electric current

Ümit Turgut \textsuperscript{a,}*, Fatih Gürbüz \textsuperscript{b}, Güven Turgut \textsuperscript{c}

\textsuperscript{a}Fataturk University, K.K. Education Faculty, Dept. of Physics Education, Erzurum 25240, Turkey
\textsuperscript{b}Fataturk University, K.K. Education Faculty, Dept. of Physics Education, Erzurum 25240, Turkey
\textsuperscript{c}Fataturk University, K.K. Education Faculty, Dept. of Physics Education, Erzurum 25240, Turkey

Abstract

The aim of this study is to identify 10\textsuperscript{th} grade students’ misconceptions related to electric current. For this purpose, an instrument composed of three-phase ten-items multiple choice electric current concept test (ECCT) was developed by the researchers. This test was administered to ninety-six 10\textsuperscript{th} grade students who were 15-16 years of age. The findings showed that 10\textsuperscript{th} grade students’ understanding of electric current is poor and also they have important and prevalent misconceptions. The results have some implications for teaching electric current, suggesting that a substantial revision of teaching strategies is needed.

Keywords: Electric current, Misconceptions, Physics education;

1. Introduction

There have been many studies conducted of students’ ideas concerning phenomena taught in science. These studies’ results show that students come to class with their existing knowledge that they construct with their experiences or formal learning (Fetherstonhaugh & Treagust, 1992). This prior knowledge is called preconceptions. Some of these preconceptions are in conflict with the scientific view. Preconceptions which are in conflict with the scientific view are called misconceptions (Driver, 1989; Tytler, 2002; Widodo, Duit & Müller, 2002). Present research has resulted with some findings about the main features of misconceptions. These findings are listed below;

- Misconceptions of students who have different culture, religion and language are frequently similar to each other.
- Misconceptions may deeply penetrate into students’ minds and resist changing.
- Daily language, culture and religion can cause the formation of misconceptions.
- Misconceptions can be parallel to the explanations made by earlier scientists in interpreting scientific phenomena.
- Misconceptions may develop after a formal teaching.

The studies on students’ misconceptions have become a central issue in science education for the past three decades (Aşçı, Özkan & Tekkaya, 2001; Çapa, 2000; Sungur, 2000; Valanides, 2000). These misconceptions affect students’ learning, since they interpret teachers’ instruction in the light of these misconceptions. Therefore, it is

* Ümit Turgut. Tel.: +90 442 231 40 10; fax:.
E-mail address: uturgut@atauni.edu.tr

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important to determine students’ misconceptions as well as their sources and develop suitable teaching strategies in order to remedy them. During the late 1980s, research in physics education showed that misconceptions are very common in all topics of physics such as mechanics (Clement, 1982; Hestenes, Wells & Swackhamer, 1992; Minstrell, 1982), electricity (Ateş & Polat, 2005; Çıldır & Şen, 2006; Küçüközer, 2003; Lee & Law, 2001; MacDermott & Shaffer, 1992; Maloney, O’Kuma & Hieggelke, 2001; Shipstone et al., 1988), optics (Feher & Meyer, 1992; Goldberg & MacDermott, 1986, 1987), and thermodynamics (Ericson, 1979, 1980; Gürbüz, 2008; Ma-Naim, Bar & Zinn, 2002; Yalçın, Altun, Turgut & Ağğul, 2009).

Because of having helical structure of physics instruction programme students continuously and progressively confront with all physics concepts year by year. For that reason, if they have misconceptions related to these concepts in primary school years, they transfer their misconceptions to the next learning levels and environments, lead to other misconceptions. Further, these misconceptions may effect university education and professional life.

1.1. Literature Review

It is believed that most of the misconceptions are originated from students’ experiences of daily life. The commonality of the misconceptions across different cultures and populations suggest that outside effects such as instructional practices, textbooks and the excessive reliance on daily language should be considered as potential sources of misunderstandings (Harrison, Grayson & Treagust, 1999; Küçük, Çepni & Gökdere, 2005).

Many studies which have been carried out to discover students’ misconceptions and learning difficulties in electric current topics have shown that students have problems in understanding electric current (Ateş & Polat, 2005; Çıldır & Şen, 2006; Küçüközer & Kocakülah, 2007; Küçüközer, 2003; Lee & Law, 2001; MacDermott & Shaffer, 1992; Maloney et al., 2001; Moreau & Ryan, 1985; Shipstone et al., 1988; Yıldırım, Yalçın, Şensoy & Akçay, 2008). These studies have revealed that students mostly can not distinguish among related concepts such as current, energy, voltage, etc. Assuming battery as a constant current source is an example of confusion between electric current and voltage. Another example is the consumption of current by electric devices within a circuit because of the confusion between electric current and energy (Bauman & Adams, 1990; MacDermott & Shaffer, 1992; Shipstone et al., 1988). These two misconceptions are the most common and resistant misconceptions among students according to the related literature.

Shipstone et al.’s (1988) study is an important research, which summarizes that students from England, France, Netherlands, Sweden and West Germany have misconceptions about electric current. In a survey done with university level students in France and Sweden (Rainson, Tranströmer & Viennot, 1994) concluded that for most of the students, electrostatics and electric circuits are two unconnected subjects. A lot of students think that current is the cause of the field, reversing the cause and the effect. Moreau & Ryan (1985) argued that although many introductory textbooks contain excellent treatments of electrostatics and electric circuits, an important connection between these two topics is often overlooked or at least not emphasized, namely that the electric potential in circuits is exactly the same as the electrostatic potential and to expect students themselves to make the connection back to electrostatics is perhaps too much. In a study in Turkey, Çıldır & Şen (2006) sought to identify high school students' misconceptions on "Electric Current" by the help of concept maps. For this purpose, research had been carried out with the contribution of two hundred forty-four 10th grade students (119 female and 125 male) from eight different schools in Ankara during 2003-2004 spring semester. At the end of study, they found that students have misconceptions of concepts like current, resistance, potential difference, electricity, generator/emk source and electric energy. In another study in Turkey, Yıldırım et al. (2008) conducted in order to identify sixth, seventh and eighth grade students’ misconceptions in electric current. For this purpose, they developed a conceptual test, which consists of 28 multiple-choice items. They administered this test to 1162 students in 12 middle schools in metropolitan Ankara. The data analysis showed that the students had a number of misconceptions about electric current and its use. It was observed that students have some difficulties in analyzing and understanding new situations when an additional resistance is put in existing circuit. It was also found that the students had misconceptions associated with such changes made in circuits and that misconceptions similar to those observed in 6th grade students are also prevalent among 7th and 8th grade students. And according to results of the study that
have suggested; instead of traditional teaching methods in science education, teaching methods should be used which can eliminate misconceptions and prevent the formation of misconceptions.

Although there have been great number of studies done to investigate the students’ misconceptions in different physics topics, there have been very few studies done about Turkish high school students’ misconceptions of the electric current. Therefore, in the present study we aimed to identify 10<sup>th</sup> grade students’ misconceptions related to electric current. Research question for this study is: “What kind of misconception have 10<sup>th</sup> grade students about electric current?”

2. Methods

2.1. Sample and Instrumentation

The aim of this study is to identify 10<sup>th</sup> grade students’ misconceptions related to electric current. For this purpose, an instrument composed of three-phase ten-items multiple choice electric current concept test (ECCT) was developed by the researchers. In order to identify misconceptions, interviews and multiple choice tests are two options that can be used. Interviews can be used to investigate student conceptions deeply. However, they can not be administered to large number of students for generalization, can not be analyzed easily, and are too much time consuming. So, multiple choice items have been most commonly used so far. Because, multiple tests can be easily administered to large number of students, are objective due to scoring, and can be easily analyzed. But, they can not investigate student answer deeply. Therefore, three-phase tests were introduced for diagnostic purposes. On the ECCT in the first phase, there are questions relating to what such an event as normal success test would be like; in the second phase, there are questions relating to the reason of the answer given to the first question; and in the third phase, there are questions relating to how sure he/she is about the answer given to the first two questions. If a student is sure for a wrong answer and the related reason he/she gives for the first two phases, then the student can be said to have a misconception. Otherwise, the wrong answer, which is due to a lack of knowledge, can not be named a misconception. During the preparation of the questions, an extensive literature scan was performed on electric current topic and questions were prepared according to the criteria mentioned in the literature. This test was piloted with thirty-two 10<sup>th</sup> grade students and modifications were made prior to the final administration of the test. To identify content validity of the test questions, tables were prepared according to the questions and topic distribution relating to the prepared questions. Then, the questions, topic distributions, and tables were controlled and edited by two expert lecturers and three physics teachers (educating 10<sup>th</sup> grades). In this study, Cronbach-Alfa reliability coefficient was calculated by using Windows-compatible SPSS-11.5 program, test’s α reliability coefficient was found as 0.75. This test was administered to ninety-six students in three 10<sup>th</sup> grade classes from different school in the city of Erzurum. Students were previously instructed about the topic in the 9th grade. Students were informed about the aim and the content of ECCT beforehand. It is emphasized that the aim of the study was not to give marks to students and therefore students were encouraged to write their ideas freely. Students were free to take their time during the administration of ECCT and on average they completed answering the questions within 40 minutes.

2.2. Data Analysis

The designed electric current concept test (ECCT) consists of 10 questions, 7 of which are selected and partially modified from the studies investigating students’ misconceptions about electric current in the literature (Shipstone et al., 1988; MacDermott & Shaffer, 1992; Lee & Law, 2001; Yıldırım et al., 2008) and 3 of them rearranged by the researchers. In these questions it is aimed to determine which kind of misconceptions about electric current subject have the 10<sup>th</sup> grade students. In the direction of this aim, statistics analysis of students responses were done and acquired symptoms were given by the sample questions. In the research, acquired symptoms were commented with the aim of determining the students’ misconceptions about electric current. One question sample in the ECCT and determined misconceptions are given below. One example of ECCT question is presented in Figure 1.
At electric circuit on the left, A and B bulbs are identical. Both bulbs are lit. Which following is correct about the (IA) passing through bulb A and (IB) passing through bulb B?

A. IA > IB
B. IA > IB = 0
C. IA = IB
D. IA > IB

Which one of the followings is the main reason for your answer?

- Bulb B consumes a portion of the current which passes on it and less current passes on bulb A.
- Bulb A consumes all the current which passes on it and no current passes on bulb B.
- Bulb A consumes a portion of the current which passes on it and less current passes on bulb B.
- As bulb A doesn’t consume the current which passes on it, same current passes on bulb A and B.

What do you think about your answer?

- Knowingly and surely
- Only guessed
- Knowingly but, not surely

In this question it is aimed to determine the misconceptions of students about electric current which is constituted by identical bulbs passing through electric circuit and connected serially. 53.12% of students considered that same current passes from A and B bulbs and the current will be saved without consumed in the electric circuit in which identical bulbs are connected serially. 26.04% of students considered that current passing through the electric circuit is completely consumed by the bulb A which is near pole positive. 13.54% of students considered that a portion of the current is consumed by bulb A. And 7.29% of students considered that a portion of the current is consumed by bulb B which is near pole negative.

As a result, in this question it is determined that students have the following misconceptions;
- The entire current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near the positive pole of battery.
- A portion of current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near negative pole of battery.
- A portion of current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near positive pole of battery.

The results of ECCT were presented in table 1 and common misconceptions examined by ECCT were presented in table 2.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Rate of Correct Answer</th>
<th>Rate of Misconception Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>%50.00</td>
<td>%50.00</td>
</tr>
<tr>
<td>S2</td>
<td>%57.29</td>
<td>%42.71</td>
</tr>
<tr>
<td>S3</td>
<td>%64.58</td>
<td>%35.42</td>
</tr>
<tr>
<td>S4</td>
<td>%53.12</td>
<td>%46.88</td>
</tr>
<tr>
<td>S5</td>
<td>%41.66</td>
<td>%58.34</td>
</tr>
<tr>
<td>S6</td>
<td>%68.75</td>
<td>%31.25</td>
</tr>
<tr>
<td>S7</td>
<td>%46.87</td>
<td>%53.13</td>
</tr>
<tr>
<td>S8</td>
<td>%70.83</td>
<td>%29.17</td>
</tr>
<tr>
<td>S9</td>
<td>%19.79</td>
<td>%80.21</td>
</tr>
<tr>
<td>S10</td>
<td>%37.50</td>
<td>%62.50</td>
</tr>
</tbody>
</table>

As seen in the Table 1, most of the students have miscellaneous misconceptions about electric current.
As the current passes through bulb 1, it divides two halves in parallel branches and joins together after flowing in bulbs 2 and 3 to flow in bulb 4.

Current does not flow and none of bulbs are lit when the switch is closed (this misconception is specific to Turkish language).

Current is consumed in the circuit.

Brightness of the bulb that is far from the battery is less than those, which are close to the battery.

Bulbs in the parallel are always brighter than those in series.

Current comes out from the positive pole of the battery and enters to the bulb where it is consumed to light the bulb which is not affected by the second wire connected between the negative pole and itself.

Current which passes on a simple electric circuit is partially consumed by the bulb.

Bulb on the branch of the opened switch is not lit and current is consumed in the circuit.

There is a proportion of the number of bulbs to their brightness. If the bulbs are in the same number then bulbs in parallel give more light than those in series.

Regardless of the circuit which is connected serially or parallel current has the same value in every point of the circuit.

Current decreases when it passes through the bulb.

Current on the positive pole of the battery is always bigger than the current on the negative pole.

Increasing resistance makes the current bigger which passes after rheostat.

The battery always supplies the same current to the circuit.

Increasing resistance makes the current smaller which passes after rheostat.

Current which passes on a simple electric circuit is completely consumed by the bulb.

Current flows to the bulb from both poles of the battery and each pole has the same value.

Point A transmits current to the bulb quicker than point B (consideration on the distance of points to the bulb).

Bulb gives more light when the number of batteries increases (independent from the type of connection).

Direction of electric current is toward from negative pole to positive pole.

Bulb becomes brighter when batteries are connected in parallel compared to batteries connected in series.

Concept of potential difference, current, power and energy are the same things.

Increasing resistance makes the current bigger which passes after rheostat. So the current before rheostat gets bigger but later rheostat gets smaller.

The entire current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near the positive pole of battery.

A portion of current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near negative pole of battery.

A portion of current passing through the electric circuit which is composed by serially connected identical bulbs is consumed by the bulb which is near positive pole of battery.

3. Results and Discussion

As a result, this study shows that a considerable number of students have misconceptions about electric current concept. It is believed that most of these misconceptions are originated from students’ experiences of daily life. The commonality of the misconceptions across different cultures and populations suggest that outside effects such as instructional practices, textbooks and the excessive reliance on daily language should be considered as potential sources of misunderstandings.

3.1. Conclusions and Implications for Teaching

As a result of this study, it was found that 10th grade students have different misconceptions about electric current. The findings of this study can be useful in science curriculum development and instructional improvement.
After identifying misconceptions, a teacher can more easily guide students gain conceptions that are scientifically acceptable by improving alternative teaching strategies. The misconceptions detected by this study can be a useful resource for teachers and curriculum developers to design effective science instructions. To promote meaningful learning, it is necessary to overcome misconceptions with the help of different instructional methods such as, cooperative learning methods, concept maps, demonstration, analogies, hands-on activities and refutational texts based on conceptual change model (Ağça, 2006; Brown, 1992; Büyükkasap, Düzgün, Erらくr & Samancı, 1998; Canpolat, 2002; Dilber & Düzgün, 2007; Gürbüz, 2008). However, successful implementation of such strategies requires that teachers have to be aware of students’ prior knowledge and their possible misconceptions and direct the classroom activities accordingly. Therefore teachers should be trained about these instructional methods and how these instructional methods could be used. In addition, each student has personal interests and many extracurricular experiences when entering the physics course. Therefore teachers must be aware of students’ prior knowledge or preconceptions about a subject and lecture materials should be designed in such a way to prevent these preconceptions to turn into misconceptions.

It was also observed that students could not distinguish between some concepts such as potential difference, current, power and energy because they were using these concepts interchangeable. Certainly, power supply as a constant current source is a result of this issue. Consequently, teachers should place more importance on teaching effectively such concepts so that students are able to grasp and overcome their inability to distinguish between them. As well as, proportions of lack of knowledge showed that students did not understand current in serial and parallel circuit. So, students must be provided with some more attempts for making them understand it. Results show that the ECCT can be validly and reliably used for assessing 10th grade students’ qualitative understanding of electric current. Therefore, teachers can use the ECCT for formative evaluation. This will give teachers feedback about if instruction needs modification, or if any individual or group remedial works are needed. Multiple tests can be easily administered to large number of students, are objective due to scoring, and can be easily analyzed. But, they can not investigate the student answer deeply. Therefore, researchers should prefer three phase tests rather than interviews, one phase tests and two phase tests in their studies.

Some misconceptions of which are emerged in our study show the need of investigation concerning misconceptions specifically originating from our country’s culture, language and teaching strategies. It is thought to be important that such language and teaching based misconceptions should be taken into consideration during teaching and activities aiming to overcome these misconceptions should be designed. It is necessary to warn teachers about the misconceptions caused by the use of language in the curriculum and in the teachers’ handbook. Finally, it should be pointed out that students generalize the ideas fairly quickly and teaching has to be supported with different activities.

References


