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Effect of Simple Electric Circuits Teaching on Conceptual Change in Grade 9 Physics Course

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ABSTRACT

The aim of this study was to examine the effect of teaching designed to consider grade 9 students' misconceptions about simple electric circuits on conceptual change. Students' misconceptions were determined by using a conceptual understanding test consisting of eight open-ended questions and semi-structured interview technique. Conceptual understanding test was applied as a pre-test at the beginning of the teaching and as a post-test at the end of the teaching while it was applied after six months later as a delayed post-test. Concept of voltage was chosen as the main concept during the teaching that was designed to support conceptual change. Misconceptions brought up in this study were presented in tables with their percentages across three tests and especially the activity concerning the misconception of "consumption of current" was examined to reveal how the ideas of the students changed in details. Mostly, the activities used for conceptual change brought about positive influences on students' ideas.

Keywords: Physics Education, Conceptual Change, Simple Electric Circuits.

INTRODUCTION

Studies about students' preconceptions in science before teaching and their change to the scientific truths have frequently been encountered in the literature from 70's till now (Pfundt & Duit, 2006). The science educators gave a big importance to the studies about the conceptual change because of the fact that students' ideas prior to teaching contradicted with the scientific truths, shown to be difficult to change those ideas with traditional teaching methods and created problems in the learning of new topics. And also they consider the difficulty of making up the students' minds by using the traditional teaching methods (Driver, 1989; Duit & Treagust, 1998; Mutimucuio 1998).

The first theory about conceptual change was proposed by Posner, Strike, Hewson and Gertzog (1982) and two kinds of conceptual change were explained in this theory by using Piaget's two terms: assimilation and accommodation. In the first one, the new concept is assimilated by the pre-conceptual structure and in the second one conceptual structure is accommodated if a student's existed concepts contradict with the newly learnt concepts. Posner et al. (1982) assert that accommodation depends on some conditions. These conditions are listed below:

- Dissatisfaction of students with the existed concept.
- Plausibility of new concept.
- Intelligibility of new concept.
- Fruitfulness of new concept.

Hewson and Hewson (1992) developed this theory and stated that conceptual change was the change of the status. They stressed that while the student's pre-concept was losing their status, the new concept was gaining their status and therefore it was understood, accepted and seen as it was useful by the student. They also emphasized that conceptual change should not be seen as a situation in which students' concepts were completely deleted or disappeared from the mind. Hewson and Hewson (1992) pointed out that it would be useful to present the meaning of the word "change" as it was used for different meanings and they described it in three different situations. In the first one the "the transformation of the frog into a prince after kissed by the princess" was given as an example. In this change, the frog was transformed into a prince, and the first situation was completely disappeared. In the second example, the help of "a bank account" described the change. The money was in the time deposit; the balance was increasing by interest. When the money was spent, the amount of the balance was decreased. Here, the change is meant by decreasing or increasing in quantities. "Two opponent politicians who live in the same city and one of them is the major of the city" was given as the third example. Both of them lived at the same city after the elections. The major lost the elections and his opponent became the major. So, while the ex-major was losing his status, the other politician gained it. In these kinds of changes, there has not been a complete disappearance of status. They only take the positions mutually. Researchers do not approve the complete disappearance during conceptual change as in the first example. In the second example, change is accepted as the assimilation or conceptual capture and it is accepted as the accommodation or conceptual exchange in the third example.

In science teaching literature, there are many teaching strategies suggested to change and improve the misconceptions during teaching (Clement 1987; Nussbaum & Novick, 1982; Stavy, 1991). Scott, Asoko and Driver (1992) separated the teaching approaches into two groups in their study so called "teaching strategies for conceptual change". While cognitive conflict and solution of the conflict based teaching strategies took place in the first group strategies, the use of analogies or metaphors was presented in the second group. The first group strategies are developed from being inspired by Piaget's views about learning. Students are made conscious about their own opinions and then an opposite event or some activities that challenge to their opinions are given. For instance, the strategy of predict–observe–explain (POE) developed by White and Gunstone (1992) takes place in this group. In the first step of this strategy, students make predictions about a situation or an event then they make an experiment or observation and express their results during the observation part. Lastly, they are asked to explain the similarities or the differences between the predictions and the observation results. In the second group, there are strategies which are built upon students' existed opinions and spread those opinions over a large area by using analogies or metaphors. The most popular strategy in these groups belongs to the Clement (1987) and Brown and Clement (1989) which is called bridging strategy.

While teaching is carried out in the frame of the constructivist learning theory, it is necessary to take students' misconceptions into consideration and arrange a learning environment where they can form their ideas by themselves. Another important issue is which of the concept should be chosen as the main concept or in which lines the concepts should be given. When examined the teaching based studies about simple electric circuits, special activities are designed to remedy the misconceptions detected. Generally, there are some different opinions about which of the key concepts should be chosen to start teaching in these studies. The studies in literature show that, most of the time it is started with one of these three concepts: voltage (Lee & Law, 2001; Psillos, Koumaras & Valassiades, 1987; Psillos, Koumaras & Tiberghien, 1988; Psillos, 1998), current (Cosgrove, 1995; Shafer & McDermott, 1992) or energy (Berg & Grosheide, 1997; Licht, 1991; Shipstone & Gunstone, 1985). When examined the teaching strategies used for the conceptual change, it is understood that cognitive conflict and analogy activities are used together most of the time.

It is very important to consider misconceptions in teaching and use different teaching strategies and activities to change them. Although the studies about conceptual understanding and conceptual change started in 1980's in Europe and America, they are very recently conducted in Turkey. Because of the fact that this study takes students' opinions about simple electric circuits into consideration and uses activities that can provide a development from students' ideas towards scientific ideas, it is thought that this study will contribute considerably to the science education literature.

The purpose of the study is to examine the effect of teaching designed to consider students' misconceptions about simple electric circuits on conceptual change. In this direction, the question whose answer is tried to be found is: what is the effect of teaching developed by using the literature and carried out to alter the misconceptions?

METHODOLOGY

Pre-experimental design, which contains one-group pre-test, teaching, post-test design, is chosen as a methodology for this study. The sample of the study is composed of 23 students in one class of grade 9 level in the city centre of Balıkesir in Turkey.

1. Collection of Data

Conceptual understanding test, which was used as a pre-test, post-test and a delayed post-test, was prepared by asking the opinions of the experts in physics education and by the help of literature (Shipstone & Gunstone, 1985; Shipstone et al. 1988; McDermott & Shaffer, 1992; Lee & Law, 2001). Conceptual understanding test consisted of eight open-ended questions and it was administered to 108 students in Grade 9 classes during the piloting phase. Thereafter, it was rearranged to put it in its final form. The final form of the conceptual understanding test was administered six months after teaching as the delayed post-test. In addition, semi-structured interviews were conducted with randomly selected 9 students after pre and post-tests. The aim of interviewing students was to examine their opinions deeply about the topic.

The activities prepared were put into practice by physics teacher of the class during the teaching. Meanwhile one of the researchers recorded the teaching atmosphere in the classroom. Teaching was carried out in two lessons' time (80 minutes) in a week and lasted for five weeks. Class teacher was informed about the general principle to be considered during teaching and about which activities should be done for each lesson before the teaching started. The general structure of teaching was presented in details below.

2. Data Analysis

In this part of the study, especially the method used in the analysis of data obtained from pre-test, post-test and delayed post-test was presented, and also the aim of designing conceptual change graphics and how they were prepared, were given. Data obtained from the interviews were transcribed and examined carefully as they could be useful in understanding of data obtained from pre-test and post-test. These data were analysed by using content analysis in qualitative data analysis methods. The video records of the class during teaching were watched by the researchers in order to understand the reasons of interesting and unexpected situations encountered when conceptual changes examined for each question and to shed light on these matters.

2.1 Analysis of Conceptual Understanding Test (CUT)

Data collected from conceptual understanding test were analyzed by the help of the approaches that require the definition of scientifically complete response (nomothetic) and the classification of explanations in certain categories (ideographic) (Driver and Erickson, 1983; Kabapınar, 1998; Kocakülah, 1999). A scientifically accepted response was determined for every question with an expert in the approach of defining the scientifically complete response. After that, it was possible to classify the students' response into two definite categories: correct and incorrect responses. Following this approach, the scientifically acceptable student answers were compared to the predetermined scientifically correct answers and they were listed in a hierarchical order according to the complexity level of each student's answer from correct answer to partially correct answer. In this respect, it was possible to see in what degree the students' answers were complex and contained several conceptual explanations with regard to being scientifically correctness. Students' responses that could not be accepted as scientifically correct were coded in the approach of classifying the explanations in certain categories. Different student responses in this approach were put into two groups in this study. While the first group involves explanations related to the simple electric circuits (incorrect 1 and 2), the second group involves explanations apart from simple electric circuits (incorrect 3). The target of this analysis was to comprehend the explanations specific to each student and to present them in certain categories.

In this study, the categories obtained from the system of coding the responses, the levels developed by the classification of categories and the meaning of each level are presented below (Küçüközer, 2004).

A – Scientifically Correct: Scientifically correct and complete explanations take part in this group.

B – Partially Correct: Responses involving correct but incomplete explanations were considered to belong to this group.

C – Incorrect 1: Ideas including both partially correct and incorrect statement sentences fall into this group. In general, statements of this group were considered as incorrect.

D – Incorrect 2: Ideas involving the concepts of electricity and explanations focusing on the minority or majority of any circuit component and the way the circuit is connected match with this group.

E – Incorrect 3: Ideas involving the concepts and explanations apart from electricity correlate with this group.

F – Uncodeable: Explanations which are difficult to understand what they imply or have no relationship with the question coincide with this group.

G –No Explanation: Students who did not make any explanation about the question and write the same expression given in the alternative of multiple – choice part of the question were put in this group.

By means of this analysis, it was determined that student explanations indicating misconceptions mostly took part in level C and level D.

2.2 Conceptual Change Diagram

In this study, diagrams that show the levels of the students in each test and the transition between levels are used and they are called conceptual change diagrams (Küçüközer, 2004). While these diagrams give the opportunity to see the level of the students and the transition between the levels, they also provide deep and clear information about the shifts in students' ideas for the researchers. Moreover, they help to see each student's progress and the retention of ideas. According to conceptual change diagrams, if the students take part in level A or level B in post and delayed post-tests, while they have misconceptions in the pre-test, it means that the change in their ideas is permanent. When they are in level A or level B in the post-test, if they go down to a lower level in delayed post-test, it means that the change in students' ideas is temporary conceptual change. The conceptual change diagram being formed for the concept of current was given in the second part of the findings section in this study.

3. The General Structure of Teaching

The basis of teaching administered in this study is based on the principle ideas of constructivist learning theory. In connection with this theory, the teaching is envisaged by considering the ideas stated as "students construct their own knowledge, students' preconceptions play a big role in the process of putting data together on their own and learning formed during their interactions within physical and social environments. Students were encouraged to work in groups, and express their ideas freely in debates. The aim of debates in groups is to make students become aware of their own ideas and their friends' ideas, make critics about them and also reorganize or change their ideas if it is needed, then in the end reconcile their differences with commonly shared meaning. In short, maximum attention was paid to develop a natural and social atmosphere rather than an isolated atmosphere while students were forming their ideas on their own (Kearney & Treagust, 2001).

Students' misconceptions about the topic, the studies made for teaching in the literature and the curriculum of first year of high school physics lessons were taken into consideration when teaching was being designed. The borders of the program define the conceptual frame of the study.

When looked at the teaching of simple electric circuits in a conceptual point of view, it is an important matter that which of the concepts should be taken as the basis of teaching; voltage, current or energy, and in which order those concepts should be taught. At the same time, constructing the other concepts around the main concept affects students' learning positively (Shafer & McDermott, 1992). Thus, teaching was designed in the basis of a main concept. There are studies that were made considering one of these concepts of voltage, current and energy as the principle concept in the literature and it is emphasized that students generally succeeded in each of them. Only Lee and Law's study (2001) was based their teaching on both current and voltage. First of all, the researchers made current based teaching but when they realised that most of the students' misconceptions still existed after teaching, they carried out voltage-based teaching and they saw that there were so many changes in misconceptions. In addition, it is thought that the concept of voltage should be taught well and then the concepts of current, resistance and also Ohm's law should be given to the students because of the fact that flow of the current in a circuit depends on the voltage provided by a battery. Therefore, the concept of the voltage is chosen as the principle concept in the study. Moreover, even if it is started with the concept of current, the necessity of giving information about the thing that causes current makes it obligatory to mention about voltage. Although beginning teaching with the concept of energy was another possibility, this was not considered in this study due to the limitations originated from the curriculum.

Cognitive conflict and predict-observe-explain strategies were mostly used in the activities prepared for the teaching. On the other hand, the simulation strategy is only used in the part related to the concept of current.

The designed teaching consists of four main sections. The first section has four, the second one has six, the third one has two and the fourth one has five activities. It has seventeen activities in total. These sections are presented and explained below in general.

- The subtitles of completing a circuit and general characteristics of electric circuits take place in the first section, which is called as "the first step to the simple electric circuits". In the first subtitle, the aim was to help the students to comprehend that it was necessary to complete a simple electric circuit correctly to provide that the bulb was lit. The objective of the second subtitle was to inform students about the operation process of electric circuits in general and to provide them to acquire some manipulative skills about circuits.

- Firstly, the activities consisting of the concept of voltage, presentation of batteries, a voltmeter and different kinds of battery connections (in serial, opposite serial and in parallel and opposite parallel) took place in the second section called 'concepts'. After the concept of current and the presentation of ammeters were introduced, some conceptual change activities related to the misconceptions of 'consumption of current', 'current flows to the bulb from both terminals of the battery' and 'batteries are constant current sources' were presented. In these activities, students were asked to make predictions about the brightness of the bulbs. In fact, one should know the concept of energy or power to express correctly the brightness of the bulbs. No activities were done about the concepts of energy and power because of the fact that the teaching of these concepts belongs to the upper class (grade 10 lessons in the curriculum). In order to eliminate this difficulty, maximum attention was paid to use identical bulbs and resistances in all activities during the teaching. As a result of this, students had to make predictions about the brightness of the bulbs considering either the voltage values between the tips of the bulbs or the current values passing through them.

- The activities that show the differences between the concepts of voltage, current and energy took part in the third section called 'the differences between the concepts'. As voltage, current and energy are abstract concepts, it is very difficult to be understood by the students. In addition, it was seen as a significant matter by the researchers to reveal the differences between the concept of energy and the concepts of voltage and current in this section, as it was frequently used during the interviews and in CUT before the teaching. Therefore, some activities that brought up the differences between the concepts of voltage-current, voltage-energy, and current-energy were done. It was benefited from the Psillos's study (1998) while these activities were being prepared.
- The activities included the concept of resistance, ohmmeter, ohm's law and the concept of equivalent resistance took place in the fourth section called "resistance-ohm's law". After the activities done about the resistance and ohmmeter, students had the chance of discovering the ohm's law on their own. Following these activities, the formulas of equivalent resistance, the current created by building circuits in serial and in parallel, the measurements of the voltage were obtained by the students. Moreover, the activities related to the connection of the resistances (in serial, in parallel and in mixed) lead the students to find the equivalent resistance by using three ways: firstly, they used the formula of the equivalent resistance, secondly they made use of the ohm's law and lastly they used the ohmmeter. At the end of the activities, some circuit problems were solved about ohm's law, circuits connected in serial, in parallel and in mixed.

FINDINGS

In this part, the misconceptions brought to light after the analysis of the data, and the changes occurred after the teaching are presented in general. In addition, the change in the misconception of "consumption of current" is examined in detail.

1. General Situation

The percentages of some of the notable misconceptions emerged in the pre, post and delayed post-tests are shown in Table 1. As can be seen in Table 1, students have some misconceptions about the simple electric circuits before teaching.

When looked at the post-test, it can be easily understood that, teaching is very effective in changing the misconceptions of number 1, 2, 3, 4 and 8. In addition, it also produces considerable changes in the misconceptions number 6, 7 and 9 in a positive way. With regard to the misconception of "batteries are constant current sources", it can be said that teaching does not make any change on it; on the contrary it supports this misconception. This situation is examined deeply below.

When looked at the delayed post-test, it can be realised that teaching is completely effective in changing the misconceptions being numbered as 2, 4 and 8 that are not responded in the delayed post-test as in the post-test. The misconceptions of number 1 and 3, which are not encountered in the post-test, are seen in the delayed post-test, but their percentages are very low when compared to their percentages in the pre-test. This finding shows that teaching is effective but it is partially efficient in terms of the permanence of knowledge. It can be said that teaching is ineffective in this conceptual area as the percentage of the misconception "batteries are constant current sources" increases in the delayed post-test.

Table 1. *The Percentages of Misconceptions in Pre-test, Post-test and Delayed post-test.*

Misconceptions	**Frequency (%)**		
	Pre test	**Post test**	**Del. Post test**
1- Consumption of current	34.8	-	17.4
2- Current flows to the bulb from both terminals of the battery and each has the same value.	13	-	-
3- The concepts of voltage, current and energy are used interchangeably with each other.	43.4	-	13
4- No bulb lights on if the switch is off.	30.4	-	-
5- Batteries are constant current sources.	39.1	60.8	78.3
6- When the number of batteries increases (independent from the type of connection), the bulb gives more light.	30.4	4.3	13
7- In the serial circuits, a change in front of a bulb is regarded as having an effect on the brightness of the bulb.	30.4	8.7	13
8- Bulbs connected in parallel give better light than those connected in series.	26.1	-	-
9- Bulbs in series always give more brightness (when ammeter and voltmeter are connected in series a bulb gives more brightness).	21.7	8.7	4.3

As stated above, there is an increase rather than decrease in the percentages of the students who has the misconceptions of ''batteries are constant current sources''. Video camera records were examined in order to determine the reasons of increase in this misconception. A special conceptual change activity was used for this misconception during the teaching. The aim of this activity was to make students aware that the batteries are constant voltage sources rather than constant current sources, by studying on four different circuits (Figure 1) in which the same battery was used in each circuit.

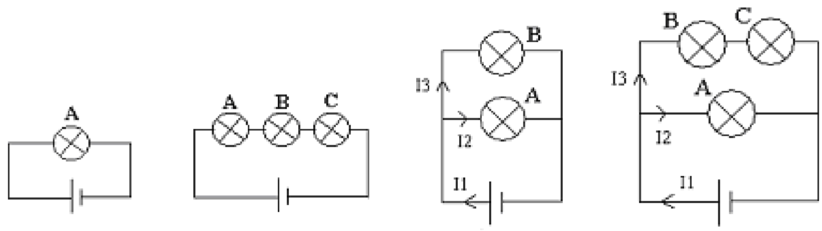


Figure 1. *The Circuit Types Used in the Activity about the Misconception that Batteries are Constant Current Sources.*

The POE technique, which was used in most activities of the teaching, was also used in this activity. At the prediction step, it was observed that almost all of the groups thought that when a change was made in the circuit there would not be any change in the value of current, which was supplied by the battery. At the observation step, since the activity was long lasted, this caused to diverge from the main purpose and to end in failure. Although the completion time of the activity had been predicted as 15-20 minutes by the researchers, it lasted for 45 minutes in reality. The cause for this situation was demanding the students to obtain too much measurement and to make comments on those measurements.

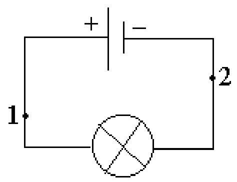
Although the main purpose was to show that the batteries are not the constant current sources, in addition the researchers also aimed to strengthen the idea that the current does not decrease after flowing through the bulb in the circuit. Thus, students were asked to measure the current values at both sides of each bulb. This situation caused the activity to be extended and diverged from the main purpose. It is a fact that all students adopted the idea of the main currents in all four circuits would be the same during group and class discussions at the beginning of the activity and the failure of the activity caused an increase in the percentage of that idea in the tests applied after teaching.

2. Detailed Examination of Data for the Concept of Current

In order to give more detailed example, which data are gained from the three tests related to the current concept and the conceptual change graphics are examined in this part. The activity of conceptual change concerning the misconception of the consumption of current is given in appendix.

The question about the consumption of current asked in CUT is also given in the Figure 2 below.

Put an X into the box, which is the correct option you think, next to the answers related to intensity of the current in the points 1 and 2 of the circuit below. Explain the answer you chose briefly.



❑ 1>2
❑ 1=2
❑ 1<2

Your explanation: ---

Figure 2. *The Question which is asked to Bring out the Misconception of Consumption of Current.*

In this question, it is required that the students should mark one of the three alternatives related to the intensity of the current in both sides of the bulb in the points 1 and 2 of a simple circuit and explain the answer they give briefly. The category and level of students' explanations given to the question in three tests are presented in Table 2.

As can be seen in Table 2, it is seen that 21.7% of the students are at level A and 4.3 % of them are at level B, totally 26% of the students gave answers which are scientifically acceptable explanations. When examined the level C and D in which the misconceptions exist, mainly 34.8% of the students have the misconception of "consumption of current" and 13% of them have the misconception of "Current flows to the bulb from both terminals of the battery and each has the same value" in the pre-test. These two misconceptions are frequently reported in the literature. The majority of the students, who were interviewed, created a cause/effect relationship and explained that the intensity of the current should decrease due to the fact that the bulb lights when the current passes on it.

Table 2. *The Percentages of the Response Categories Composed by the Explanations Given in Three Tests*

Level	Categories	Frequency (%) Pre-test	Post-test	Del. Post-test
A	Current has the same value in every point of the circuit (Conserved).	21.7	87	56.5
B	1- Because of the fact that energy in the circuit is the same, the current is also the same.	4.3	-	-
	2- As the voltage of the conductive wires is zero (equal), the currents of these points are also equal.	-	8.7	8.7
	3- As the resistance of the conductive wires is zero, the current values of these points are equal.	-	-	4.3
C	The current is equal at those two points; it is divided in the bulb.	-	4.3	4.3
D	1- Consumption of current.	34.8	-	17.4
	2- Current flows to the bulb from both terminals of the battery and each has the same value.	13	-	-
E	The current in point 1 is bigger than the current in point 2 as it is close to the bulb.	4.3	-	-
F	Uncodeable	17.4	-	8.7
G	No explanation	4.3	-	-

In the post-test, it is found that 87% of the students are in level A and 8.7% of them are in level B, totally 95.7% made explanations which are scientifically acceptable. This data show that the conceptual change activity (see appendix) about the concept of current is quite effective. All of the interviewed students explained that the current does not decrease when it flows through the bulb. They explained that they understood this point by the measurement they made with the ammeter during the experiments. While 6 of these students accepted that their former ideas were false, the remaining 3 students were still observed to experience cognitive contradiction.

When the delayed post-test results are examined, 56.5% of the students are in level A and 13% of them are in level B, totally 69.5% of them are observed to make scientifically acceptable explanations. In this test, the percentage of correct explanations decreases at the proportion of 30% when it is compared to post-test. While the percentage of misconception of “consumption of current” is 34.8% in pre-test, none of the students reasoned with this misconception in post-test and it is encountered with this type of misconception in the proportion of 17.4% in delayed post-test again.

After a general overview, how the change occurs in which level of the students is examined with the conceptual change graphics. Levels and transition between those levels of each student in pre, post and delayed post-tests are presented in Figure 3 for this question.

When the Figure 3 is examined, it is evident that students are accumulated in levels D (11 students), A (5 students) and F (4 students) of the pre-test and in level A (20 students) of the post-test and in levels A (13 students), D (4 students) and B (3 students) of the delayed post-test.

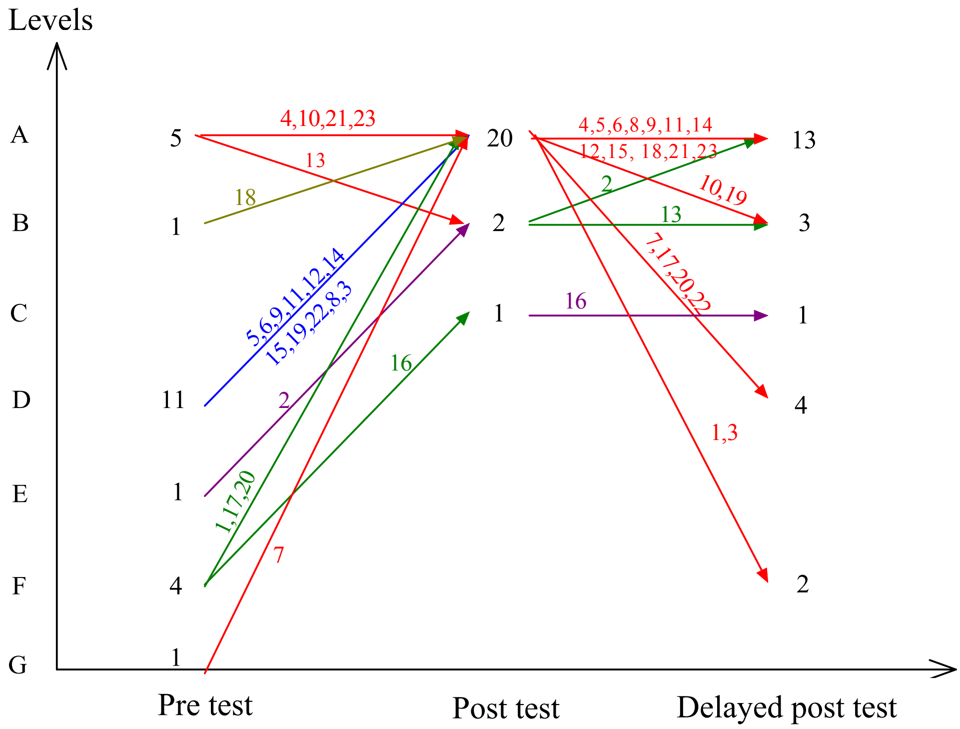


Figure 3. *Levels and Transitions between the Levels of each Student in Pre-test, Post-test and Delayed post- test.*

In the post-test, students, who responded in scientifically acceptable levels of A and B in the pre-test, preserved their levels. They are the students coded as 4, 10, 13, 21, 18 and 23.

In the post-test, majority of the students in level A were observed to be consisted of the students who were in level D in the pre-test. Eleven students, who were coded as the students 3, 5, 6, 8, 9, 11, 12, 14, 15, 19 and 22 in this test, progressed to level A. Furthermore, eight of those students preserved their levels in delayed post-test. This result shows that the teaching is fairly effective on this subject. Above, during the interpretation of Table 2 it was explained that the proportion of 34.8% (pre-test) about the misconception of "the consumption of current" was zero in the post-test and it was 17.4% in the delayed post-test. These percentages can make us think that the conceptual change activity related to the subject are half effective, however when we look at the students' transition between the levels, 17.4% of the students do not come from the 34.8% of students in the lower level (level D) of the pre-test.

Besides the change, when permanence of knowledge is considered, those students 2, 5, 6, 8, 9, 11, 12, 14, 15, 18 and 19, who were in level A or B, stayed in their levels in the delayed post-test that shows permanent conceptual change occurred in their ideas. For example, in pre-test student 8, who had believed in a scientifically unacceptable way that "the current coming from the battery is consumed while passing from points 1 to 2, as a result 1 is bigger than 2", made explanations which were scientifically acceptable in the post and delayed post-tests. These explanations were "the current coming from the battery is the same in all parts of the circuit" in the post-test and "as the current flows in the circuit with the same intensity it is not consumed at the bulb" in the delayed post-test respectively. Students 7, 17, 20 and 22, who fell from level A or B in post-test to level D, and students 1 and 3, who fell to level F in delayed post-test, had temporary conceptual change in their ideas. For example, student 17, who stated in pre-test that ''the electricity first passes to the current strength number 1'', made a scientifically acceptable explanation of "The current is the same until it completes the circuit, because the circuit is serial connected" in post-test. However, this student stated again in a scientifically unacceptable way which belongs to level D and reasoned that "as it is at the positive direction 1>2" in the delayed post-test.

CONCLUSION AND DISCUSSIONS

In this study, it is aimed to examine the effect of the teaching, which takes student's misconceptions into consideration and is based on the concept of voltage, on the conceptual change. The most general result of the study is that teaching mostly enabled the students to make scientifically acceptable explanations in both post and delayed post-tests.

Following the teaching, the misconceptions related to "the consumptions related to current", "currents come from both terminals of the battery and they have the same intensity", "usage of voltage-current-energy in place of each other", "no bulb lights of when the switch is off" and "bulbs connected in parallel give better light than those connected in series" are not seen in the post-test. Those misconceptions of "as the battery number increases the brightness of the bulb also increases", "a change made before the bulb effects the brightness of the bulb in a serial circuit" and "bulbs in series are brighter" are mentioned by small number of the students but the frequency of the misconception of "batteries are constant sources of current" increased compared to the pre-test.

In the delayed post-test which was administered six months after the teaching none of those misconceptions of "current flows from both terminals of the battery and each have the same value", "no bulb lights when the switch is off" and "bulbs connected in parallel give better light than those connected in series" are encountered. Teaching became effective to change those misconceptions and created permanent conceptual changes in students' ideas. Those misconceptions of "the consumption of current", "usage of voltage-current-energy concepts in place of each other", "as the battery number increases the brightness of the bulb also increases", "in a serial circuit a change made in front of the bulb effects the brightness" and "the bulbs connected in series light brighter" are seen in small percentages. When it was looked at on the dimension of the permanency of the knowledge, this result showed that students did not forget the knowledge they gained during teaching although some time passed. Again, as it was in the post-test, the percentage of the misconception of "batteries are the constant current sources" increased.

When generally overlooked to both post-test and delayed post-test except from the "batteries are the constant current sources" misconception, it can be concluded that teaching has been effective on establishing conceptual changes in the other misconception types.

The methodological approach used in the research, especially the conceptual change graphics are important materials to be used for this kind of researches. Although the misconceptions, which were detected before teaching in the pre-test, appeared in the post and delayed post-tests again after the teaching might cause to have an idea that teaching had no effect, conceptual change graphics showed that the situation was different in fact. Bringing out the ideas of each student both before and after the teaching and expressing them in graphics enabled us to have more reliable results.

Teaching techniques that had been arranged, except the misconception of ''the batteries are the sources of constant current'', were performed without any problem and they became effective. For example, the conceptual change activity about ''the misconception of the consumption of current'' was really helpful. When looked at the past studies conducted on this subject, mostly the cognitive conflict technique is observed to be used. The most frequently applied activity included students' awareness of the equality of the current values by using ammeters placed on both sides of the bulb. Although this activity is stated to be effective in many studies, Psillos (1998) states that students perceive the ammeters as the circuit materials that consume the current. This situation might also be stated by our own students, so in the activity placed in the appendix, third ammeter was also used. In the literature, most researchers stress that although the change related to the idea of consumption of current is partially gained, some problems about this misconception continue (Berg and Grosheide, 1997; Psillos et al., 1987; Shafer & McDermott, 1992;). As a result, although it is different from the literature, the use of the third ammeter became effective to change this misconception in this study. The sample activity we used related to the misconception of batteries is the constant current sources is benefited from the activities which Lee and Law (2001) and Shafer and McDermott (1992) used in their studies. Although Lee and Law (2001) state that a positive change occurs in the ideas of the students, Shafer and McDermott (1992) stress that there is a partial change but students need special help about this subject. The data obtained from the study we conducted show that the activity used to remedy this misconception does not yield effective results in terms of conceptual change.

SUGGESTIONS

In this part, according to the results of the research, some suggestions are given about the quality of the teaching designed and the studies to be conducted in the future.

- Because most of the activities used during teaching to change considered misconceptions served the research purposes, these activities are suggested to be used by teachers and researchers in future.
- It has been put forward with data obtained that the activity used related to the consumption of the current is brought up to be a suitable activity showing that neither the bulbs nor the ammeters use the current. This activity can be used as an activity aiming the conceptual change by primary science and physics teachers.
- If it is isolated from the situations of leaving the purpose and lasting the time of the experiment, the activity about the misconception of ''batteries are the constant current sources'' can be used as a successful conceptual change activity.
- The effectiveness of the teaching style adopted in this study can be tested in other grades of high schools.
- Ministry of National Education puts a new curriculum into practice that realises the misconceptions in the frame of the constructivist theory in the primary level and activities that include conceptual changes. As the misconceptions effect the students' learning of a new subject in a negative way, conceptual change activities should take part in teachings at high school level by including them in secondary science curriculum.

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APPENDIX

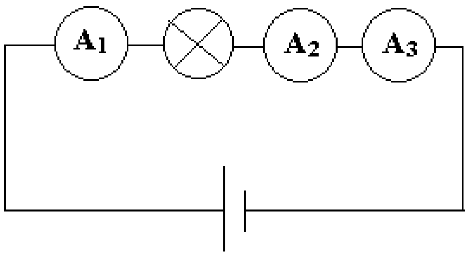
A conceptual change activity prepared for the misconception of "consumption of current".

Let's Examine Closely The Current Flowing Through A Circuit

Equipments: A power supply, three ammeters that have pointers stood in the middle, an electric bulb and five crocodile type conductive wires.

- In the circuit below, ammeter A_1 shows the value of 0.06 Ampere. Please put an X into the box next to the alternative that you think is the correct answer about the current measurement of ammeter A_2 and ammeter A_3. Explain your response briefly.

❒ A_2=0.05 Ampere	❒ A_3 = 0.04 Ampere
❒ A_2=0.06 Ampere	❒ A_3 = 0.05 Ampere
❒ A_2=0.06 Ampere	❒ A_3 = 0.06 Ampere
❒ A_2=0.07 Ampere	❒ A_3 = 0.08 Ampere



Set up the circuit shown in the figure.

- Note down the current value passing through each ammeters.

A_1 = ……A A_2 = ……A A_3 = ……A

- Are there any differences between your responses and experimental results? If so try to explain its reason.

P.S.: The activities used for changing the other misconceptions during teaching can be given to the readers if they get into touch with Assist. Prof. Dr. Hüseyin Küçüközer by this e-mail: hkucuk@balikesir.edu.tr.