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Combining Different Conceptual Change Methods within Four-Step Constructivist Teaching Model: A Sample Teaching of Series and Parallel Circuits

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Based on students' alternative conceptions of the topics 'electric circuits', 'electric charge flows within an electric circuit', 'how the brightness of bulbs and the resistance changes in series and parallel circuits', the current study aims to present a combination of different conceptual change methods within four-step constructivist teaching model. Therefore, the author assumes that such a design may give a chance to eliminate students' alternative conceptions fully. Also, some suggestions were made for further research.

Key Words: conceptual change, constructivism, series and parallel circuits

Introduction

Since science contains many abstract concepts, students may learn them in different ways called *'misconception', 'pre-conception', 'pre-existing knowledge', 'children's science'* etc (e.g. Nakhleh, 1992; Nicoll, 2001; Osborne, Tasker & Schollum, 1981). Why students hold alternative conceptions can be explained by several reasons: teaching method, student pre-existing knowledge, insufficient connection between concepts or between pre-existing knowledge and new one, textbook, procedural learning and so forth (Aubrecht & Raduta, 2005; Dikmenli & Çardak, 2004; Özkan, Tekkaya, Çakıroğlu, 2002). Since students' alternative conceptions are very common even if different cultures and countries are (e.g. Çetin, 2007; Goh, Khoo, & Chia, 1993; Keleş & Çepni, 2005; Tan, Taber, Liu, Coll, Lorenzo & Li, 2008; Vosniadou & Brewer, 1987), science education studies have focused on the following questions; "how to teach?", "why to teach?", "whom to teach?". Since student's pre-existing knowledge is central for further learning, physics studies, as in case of the other disciplines, have made an attempt to elicit students' alternative conceptions of some perspectives such as heat and temperature (Eryılmaz & Sürmeli, 2002; Frederik, Van Der Valk, Leite & Thorén, 1999; Havu- Nuutinen, 2007), force and motion (Keleş, 2007; Rowlands, Graham, Berry & Mcwilliam, 2007; Yürük, 2007), energy (Ametller & Pinto, 2002; Hapkiewicz, 1992; Kurt, 2002), mechanics (Clement, 1987; Oliva, 2003), electricity and magnetism (Choi & Chang, 2004; Demirci & Çirkinoğlu, 2004; Michelet, Adam, & Luengo, 2007), mass and weight (Hapkiewicz, 1992; Koray, Özdemir & Tatar, 2005; Moore, & Harrison, 2004) and so on.

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Because electricity is one of the most important topics in physics curricula (Ateş, 2005; Borges & Gilbert, 1999), much research has been conducted to define students' understanding, their alternative conceptions and their mental models. Especially, in the context of this study, the topics 'electric circuits', 'electric charge flows within an electric circuit', 'how the brightness of bulbs and the resistance changes in series and parallel circuits' have investigated well (e.g. Clement & Steinberg, 2002; Duit & Rhöneck, 1998; Grotzer & Sudbury, 2000; Periago & Bohigas, 2005; Psillos, 1998). The related studies have reported that students have alternative conceptions of the aforementioned concepts because of their little academic knowledge about electric circuits (Clement & Steinberg, 2002), their learning difficulties (Duit & Rhöneck, 1998), their pre-existing knowledge (Duit & Rhöneck, 1998) and their misunderstandings or confusions (Psillos, 1998). The related alternative conceptions are outlined by some models: (a) 'sink theory (unipolar model)' ; one wire between a bulb and a battery is enough to light the bulb (Kärrqvist, 1985; Fredette & Lochhead, 1980); (b) 'clashing currents (two-component model)' theory; current leaves from the positive terminal and negative current leaves from the negative terminal of the battery and they meet and produce energy in the bulb (Kärrqvist , 1985 cited in Borges & Gilbert, 1999, p.98; Osborne, 1983); (c) 'closed circuit model'; electrical current flows in a given direction around a circuit, each device in the circuit uses up some of the current so that current weakens (Kärrqvist , 1985 cited in Borges & Gilbert, 1999, p.98); (d) 'current consumption model'; current travels around the circuit in one direction and the devices in the circuit share the current equally; however less current returns to the power source than originally leaves (Kärrqvist , 1985 cited in Borges & Gilbert, 1999, p.98); (e) 'constant current source model'; the current supplied by the battery is always the same regardless of the circuit features (Kärrqvist, 1985 cited in Borges & Gilbert, 1999, p.98-99). However, identifying or labeling students' alternative conceptions is not enough to overcome them (e.g. Çalık & Ayas, 2005a). Therefore, to achieve effective learning, much research has attempted to devise such conceptual change methods as analogy (Choi & Chang, 2004; Cosgrove, 1995; Paatz, Ryder, Schwedes & Scott, 2004), worksheet (Loureiro & Depover, 2005; Yiğit & Akdeniz, 2003), conceptual change text (Ateş, 2005; Chambers & Andre, 1997), learning cycle model (Ateş, 2005; Huyugüzel Çavaş & Yılmaz, 2006) to help students to change their alternative conceptions towards scientific ones. If a conceptual change method such as conceptual change text, analogy and so forth often exploits itself, students may be fed up, thereon, this may impede to attain effective results (Dole, 2000; Huddle, White & Rogers, 2000). Also, Chambers and Andre (1997) point out that even if conceptual change text is effective in overcoming students' alternative conceptions, a hands-on activity that students experience explicitly may sometimes be more efficient.

Despite the fact that constructivism stresses to take students' alternative conceptions into consideration, teacher may not incorporate them in his/her teaching experience since they do not know how to exploit them (e.g. Çalık & Ayas, 2005a; Driver & Oldman, 1985; Fensham, Gunstone & White, 1994; Matthews, 2002). Therefore, using different teaching methods together in a constructivist perspective may solve this problem. Further, we assume that using different conceptual methods within four-step constructivist teaching model may eliminate students' alternative conceptions fully.

Four-step constructivist teaching model

In brief, since students participate actively in their learning process in tenets of constructivism, they construct their own knowledge through their experiences. Constructivism has three main characteristic; (1) learning is an active process, (2) students construct their knowledge by means of their pre-existing one, (3) learner is responsible from his/her own learning (Freedman, 1998).

To enhance applicability of constructivism, some models such as 3E, four-step constructivist teaching model (named 4E by Bodzin, Cates and Price, 2003; Bodzin, Cates, Price & Pratt, 2003), 5E and 7E are generated. Since Çalık and Ayas (2005b), Çalık, Ayas and Coll (2006) and Çalık, Ayas, Coll, Ünal and Coştu (2007) turned out many advantages of four-step constructivist teaching model rather than the others (i.e. whilst 3E (learning cycle) lacks of a phase activating students' pre-existing knowledge and motivating them, teachers are confused *elaboration* with *evaluation* for 5E model and *extension* with *expansion* for 7E model), we preferred it. Now we will introduce four-step constructivist teaching model concisely.

In first phase, eliciting students' pre-existing ideas, teacher tries to enhance students' motivation for topic, to become aware of their pre-existing knowledge and/or alternative conceptions so that (s)he has a chance to identify appropriate activities. In second phase, focusing on the target concept, teacher attempts to enrich learning environment for students, engage them in activities and to afford them to experience about concepts. Also, teacher fosters students to think about the related concept by asking questions. However, (s)he refrains from any clue. In third phase, challenging students' ideas; students compare their prior knowledge with their newly structured one. Teacher makes reasonable explanations to confirm/disconfirm their gained experiences. In last phase, applying newly constructed ideas to similar situations; students apply their new newly structured knowledge to new situations to reinforce them (e.g. Ayas, 1995; Çalık & Ayas, 2005b; Çalık, Ayas & Coll, 2006; Çalık et al., 2007).

The aim of this study is to present a sample teaching design using different conceptual change methods embedded within four-step constructivist teaching model. The alternative conceptions we focused on are as follows: *electric circuits; series and parallel circuits, the brightness of bulbs series and parallel connection of circuits*.

Teaching design

Now we will illustrate our teaching design step by step.

Eliciting students' pre-existing ideas

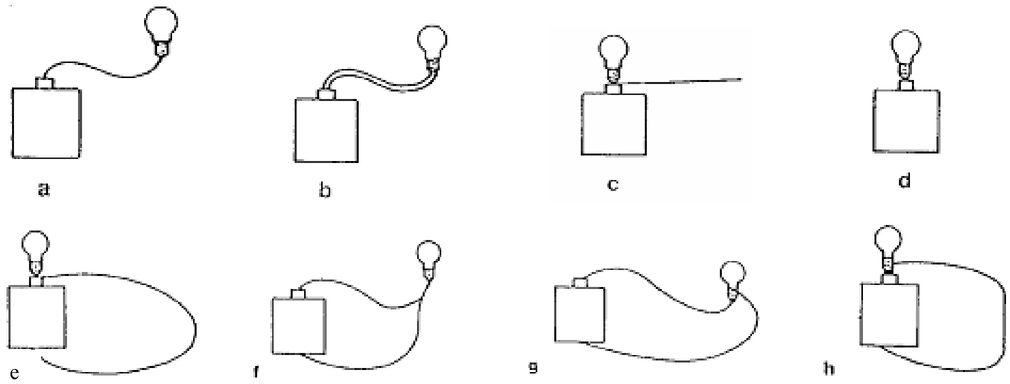
To activate students' pre-existing ideas, teacher asks the first question at the beginning of conceptual change text: 'Suppose that you have a bulb, wires and a battery. How could you fit the circuit? What do you think about which of the subsequent eight circuits work(s) the bulb? Then, teacher hands conceptual change text (Figure 1) out and allows them to read it in five minutes. After completing reading, a class discussion is conducted to get students to refute their alternative conceptions.

Focusing On the Target Concept

In this phase, the first question in worksheet is asked: "I want to increase brightness of the bulbs in my garden, which one (series or parallel connection) provides a more brightness". Students are divided into small groups of 3-4 students before worksheet is handed out. Then students are asked to follow and conduct the given directions in their small groups (except for the last questions at the bottom of the worksheet). Teacher not only monitors them but also fosters them to focus on the given phenomena, however, refrains from any clue. The worksheet is illustrated in Figure 2.

Some students believe that one wire between a bulb and a battery is enough to light the bulb. This view is called "sink theory" of electricity. But the "sink theory" is wrong because sink theory means that electricity leaves a battery, goes to an electrical device through a single wire and turns back to the battery. The current cannot complete the circuit with a single wire. The circuit should be completed to form electricity current.

Some students think that positive current leaves from the positive terminal and negative current leaves from the negative terminal of the battery and they meet and produce energy in the bulb. This view is called "clashing currents" theory. But the "clashing currents" theory is wrong. Current travels from "+" terminal and then completes the circuit by passing all circuit elements. Finally, it reaches to the "-" terminal.



Some students believe that the circuit elements have two connections. That is, electrical current flows in a given direction around a circuit and each device in the circuit uses up some of the current, thereby, current weakens. This view is called "closed circuit model". This view is wrong. In fact, the current may not be utterly conserved because of some aspects of elements of circuits such as resistance, energy change (a bit light and heat). However, this is a constant circulation since the same current flows into the circuit. Finally, the current is conserved.

Some students think that current travels around the circuit in one direction and the devices in the circuit share the current equally; however less current returns to the power source than originally leaves. This model is called "current consumption model". This view is wrong because current has the same value in every point of the circuit and is conserved.

Some students think that the current supplied by the battery is always the same whatever the circuit's features are. This view is called "constant source model". This view is wrong because the battery is seen as a source of constant current.

To generate current in an electric circuit there must be a closed circuit. Electric charges transfer their kinetic energy to each other with the help of electrical source so that electrical energy emerges. Current is formed from "+"pole to "-"pole when the charges start to flow in a battery. Finally, as seen from the foregoing studies, "g" and "h" are the correct ones.

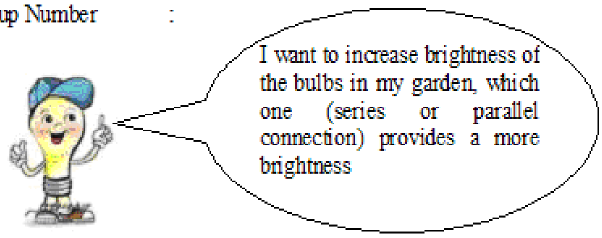
Figure 1. Conceptual change text which is devised based on the studies by Borges and Gilbert (1999), Chambers and Andre (1997), Cheng and Kwen (1998) and Grotzer and Sudbury (2000).

Challenging Students' Ideas

Since each group completed the activities presented in worksheet, a class discussion is conducted to get students to be conscious their peers' notions. To highlight brightness of series and parallel circuits, an analogy is used to make unfamiliar familiar. Such a strategy is needed since students' profiles and learning types are different from each other. By doing this, teacher clarifies the related situation and confirms/disconfirms students' acquired knowledge. The first analogy illustrates the flow of current to the bulb in simple circuits and series circuits while the second one explains brightness of bulbs in parallel circuit. By using analogy maps, teacher enables students to perceive similarities and differences. Moreover, teacher should explain the relationship between the current and brightness by means of formula; $P= I^2 .R$ (P: Power, R: Resistance, I: Current). In regard to formula, when the current increases, there is an increase in square of the current in terms of the brightness of the bulb since R is a controlled variable.

Name- Surname :
Group Number :

Devices:
- equivalent bulb
- battery
- wire



You can help me to solve this problem after completing the subsequent activities. Please follow up the given directions carefully and answer the given questions

1. Please constitute a circuit by using a bulb, battery and wires and draw its shape.

2. Please constitute a series circuit by using two bulbs, battery and wires and draw its shape.

3. Please constitute a parallel circuit by using two bulbs, battery and wires and draw its shape.

- Please compare brightness of the bulb in step 1 with that in step 2 in terms of their differences.

....

- Please compare brightness of the bulb in step 2 with that in step 3 in terms of their differences

....

- Based on your experience, what can you say about brightness of bulbs in series and parallel circuits.

....

Please apply your gained experience to the following questions

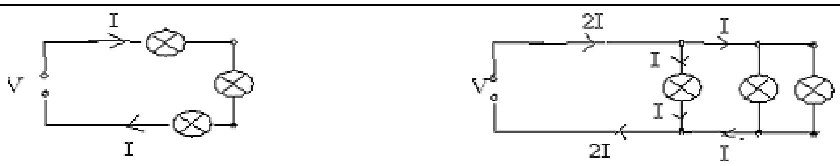


Figure 1 Figure 2

1. As can be seen from Figure 1 and 2, there are three bulbs in both series and parallel circuits. What do you consider on which of bulbs (series or parallel circuit) has a more brightness?

....

2. Which of the circuits (parallel and series) exists in your house? Please defend your response

....

Figure 2. Student's worksheet.

Analogy 1

Mr. Ali is the owner of a cloth shop in Sugar Street which has a crowded population. Mr. Ahmet is a truck driver who carries the clothes from factory to clothes store. Every week Mr. Ahmet carries the clothes from factory to Mr. Ali's clothes store (see Figure 3). Since Mr. Ali's first shop made a more benefit, he decided to open another store in Sugar Street (see Figure 4). However, because of quota of production Mr. Ahmet must divide the carried clothes between two stores. In brief, each of the stores takes half of the carried clothes.

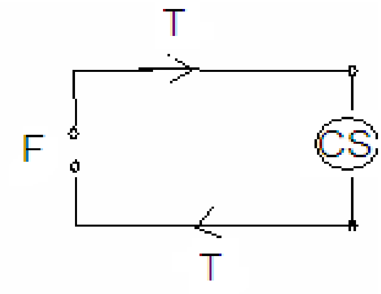


Figure 3

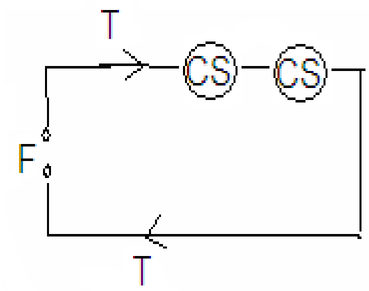


Figure 4

CS: Cloth Shop; T: Truck; F: Factory

Analogy 2

Mr. Ali is the owner of a cloth shop in Sugar Street which has average population. Mr. Ahmet is a truck driver who carries the clothes from factory to clothes store. Every week Mr. Ahmet carries the clothes from factory to Mr. Ali's clothes store (Figure 5). Since Mr. Ali opened another clothes store in the Chocolate Street, at the behind of Sugar Street, to reduce his carrying time, Mr. Ali employs Mr. Hasan's truck whose loading capacity is equal to that of Mr. Ahmet. Whereas Mr. Ahmet carries the clothes to Sugar Street, Mr. Hasan does them to Chocolate Street (Figure 6). Both of the stores have one filled truck since production quota is restricted with two filled trucks.

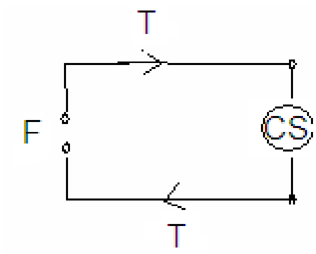


Figure 5

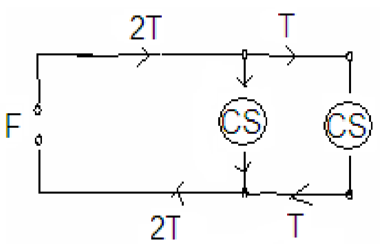


Figure 6

To apply newly constructed ideas to similar situations

To reinforce students newly structured ideas, teacher asks the following questions (at the bottom of worksheet) to students (see Figure 2). Further, teacher can exploit these questions: (1) If we connect another bulb to a parallel circuit, how does the brightness change? (2) Consuming a less energy, how can we obtain a more brightness?

Table 1. Analogical mapping for analogy 1 and 2.

Analog Feature	**Comparison**	**Target Feature**
To manufacture clothes to sell in the store.	Compared to	To produce the electrical energy flowing in circuit.
The truck moving in the mentioned street	Compared to	Current that flows in circuit
To divide the carried clothes between two stores in the same street because of quota of production, that is, each of the stores takes half of the carried clothes.	Compared to	To divide the current into two bulbs at the same series, that is, each of the bulbs has half of the current.
Two trucks, whose loading capacities are equal, move in two different streets	Compared to	Current passing through parallel circuit provides the same brightness in each bulb
Since two trucks deliver the clothes to the stores in different streets, they turn back to factory.	Compared to	Current dividing into parallel circuit
Production quota and delivery date	Compared to	Battery life
Clothes store	Doesn't compare to	Resistance in circuit because when the current comes to bulb it comes across with a resistance and loses a little energy
Truck delivers the clothes to the store.	Doesn't compare to	Electricity current because it transfers with electrons
Production quota and delivery date	Doesn't compare to	Battery life because it incorporates a more complex process

Implications for Practice and Research

To teach brightness in parallel and series circuits, especially by distinguishing from each other, combining different conceptual change methods within four-step constructivist teaching model is displayed here. Our observation in pilot study reveals that the foregoing activities within four-step constructivist teaching model not only result in a better student engagement but also enhance their motivations. However, the study has not investigated the degree to which conceptual change is achieved. For this reason, since we observed its applicability in our pilot-study, further research is supposed to concentrate on the aforementioned limitation by organizing a comparative study.

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