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HOW EFFECTIVE IS "CONCEPTUAL CHANGE APPROACH" IN TEACHING PHYSICS?

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Abstract
Both at home and abroad, the majority of the studies carried out in teaching physics is about students' misconceptions and ways of overcoming this problem. This results from the fact misconceptions are the most significant factor that negatively contributes to students' academic success. It has recently been observed that most studies discuss the process of "Conceptual Change Approach" so as to eliminate the misconception problem and improve students' learning. The "Conceptual Change Approach", whose aim is to deal with students' misconceptions regarding concepts, principles and phenomenologies in physics, embodies many strategies. This research presents some studies that have proven the effectiveness of conceptual change strategies in recovering students' misconceptions. This study, together with some suggestions, explains how it is possible to do so with "Conceptual Change Approach" in detail.

Key Words: misconception, conceptual change approach, teaching physics.

INTRODUCTION

Everyday, we come across physics in various fields, and in different ways. This gives us a general idea about some of the concepts in physics. However, sometimes, these concepts, which have developed in line with our past lives, do not match scientific facts. Those lives that do not overlap with scientific facts lead to misconceptions.

The word "concept" can be defined as "referring to the common characteristics of similar or sometimes even different objects and events with one word, or one term." On the other hand, in a broad sense, "concept" is information structure that represents the changeable common characteristics of different objects and phenomena, it is assigned meaning in our minds, and it can be expressed with one word, and is shaped as a result of people's opinions (Çeliköz, 1998).

Concepts mean a lot in physics. Misconceptions obstruct the structuring of the acquired knowledge. To avoid that and for meaningful learning, we need to revise the old information and replace the wrong one with the right one. This is called "Conceptual Change Process." (Smith, Blakeslee and Anderson, 1993)

"Conceptual Change Approach" has been put forth by Posner, Strike, Hewson and Gertzog (1982). This approach represents a perspective that grounds on Piaget and Zeitgeist's views, yet it has been improved by Posner and his colleagues. The purpose of this approach, which is an alternative strategy based on Piaget's principles of assimilation, regulation and counterbalancing, is to encourage students to remove misconceptions in their minds, and instead learn scientific knowledge (Wang and Andre, 1991; Chambers and Andre, 1997). When assimilating, they compare the concepts with their old knowledge, and add more information to restructure it. Yet, sometimes, their old knowledge may be incomplete or downright wrong. That is why the existing concepts must be revised and redefined. When their old knowledge do not match scientific concepts; in other words, when they develop misconceptions, they cannot learn well. Hence, conceptual change process must be considered with utmost care and both knowledge must be counterbalanced.

The “Conceptual Change Approach” that was brought up by Posner et al (1982) is fundamentally based on four conditions; first of all, the student must be aware that the old concept he knows is inadequate (dissatisfaction); secondly, the new concept must be understandable (intelligiblity); thirdly, the new concept must make sense to the student (plausibility) and he should be able to easily picture it in his mind, and finally, the new concept must be beneficial to him (fruitfullnes); that is, he should be able to solve similar problems with the new concept in the future.

Students do not change their minds easily, so they resist to change. As a result, it takes them a long time to learn the right scientific terms (Schmidt, 1997). This is a tiring and a very difficult process. Actually, a misconception is not a wrong answer caused by faulty or missing information. It is information that is completely different from the scientific definition of a concept. If students try to justify their wrong answers with some reasons, and they are positive about that, then we should speak of misconceptions. In other words, all misconceptions are faulty information; on the other hand, all faulty information is not misconceptions (Eryılmaz and Sürmeli, 2002). Right at this point, it is of crucial importance to incorporate conceptual change process.

The new curriculum of physics courses at secondary schools have been redesigned with a constructivist approach. The most sigificant requirements of constructivist approach is that the teacher should guide rather than teach. He brings out students’ old knowledge, corrects the misconceptions if there are any, makes up for missing information, and finally enables them to participate in class actively. In addition, he gives examples to students from daily life so that they can associate their old knowedge with the new one. He encourages his students to adopt scientific methods. Constructivism, which is closely associated with “Conceptual Change Approach”, comprises many strategies that teachers can use to spot their students’ misconceptions and correct them.

The studies illustrate that one of the most critical issues in teaching science is misconceptions. Overcoming those and the deficiencies has a major role in making learning effective and permanent (Osborne and Freyberk, 1996). In the studies that aim to convert students’ misconceptions into scientific understanding so as to develop personal conceptual image schemas, researchers generally use conceptual change texts, concept mapping, analogies, and extra materials (Stavy, 1991). What underlies “constructivism” is students’ structuring the information on their own, and learning becomes meaningful throughout the process of conceptual change approach. This approach, which aims to correct students’ misconceptions regarding concepts, principles and phenomena in physics, consists of many strategies. This survey examines the researches that have studied the effectiveness of those strategies. This is a compilation of those studies. It includes research articles, compiled articles, published and yet to be published master’s and PhD dissertations.

Conceptual Change Texts

When students first start learning physics, they bring along some information that is totally different from scientific information and one that prevents effective physics teaching. They believe that this information teaches them important things about the world. Those misconceptions in physics boks or physics classes cannot be spotted by a traditional way of education (Dewey et al, 1992). Therefore, selecting the right strategy to be used in the newly designed physics curriculum of secondary schools, which has adopted the constructivist approach, is the most important factor in identifying students’ misconceptions.

Conceptual change texts specify students’ misconceptions, clarifiy their reasons, and explain why they are not good enough with solid examples (Guzzetti et al, 1997). These texts always start with a question to activate that misconcepton in the students’ minds. In the next step, the most commonly used misconceptions concerning that topic are presented, and students are convinced why they are wrong by giving them various evidences. Here, the purpose is to enable students to question those concepts, and see the inadequacy of what they know. When they are able to do so, they are provided with a new set of information, examples so as to replace the misconception in their minds with the correct one (Pınarbaşı and Canpolat, 2002).

Conceptual change texts present new theories to refute the old ones. When the researches on teaching physics have been observed, we have found many studies on the effectiveness of conceptual change texts (She, 2003; Başer, 2006; Başer and Geban, 2007; Karakuyu and Tüysüz, 2011). In some of the researches; on the other hand, the effectiveness of conceptual change texts has been researched with a different method (Hırça, 2008). Those studies have all proven the effectiveness of conceptual change texts.

The literature review has shown us that in order to prepare conceptual change texts, the primary thing to do is to reveal what students already know besides their misconceptions. This is a very effective strategy not only for getting rid of students' misconceptions, but also diagnosing them. The studies show that those texts are used to substitute their old and wrong knowledge with new scientific one. With the help of conceptual change texts, students have questioned their misconceptions, and noticed that they do not know enough. The studies have shown that they have replaced the unscientific concepts with scientific ones after reading conceptual change texts. As a result, that change has reorganized the information in the students' minds.

Concept Maps

In addition to conceptual change texts, concept maps are another frequently used tool to make learning in science and physics meaningful (Czerniak and Haney, 1998; Williams, 1998; Guastello, Beasley and Sinatra, 2000; Sungur et al, 2001; Tekkaya, 2003; Uzuntiryaki and Geban, 2005; Kwon and Cifuentes, 2009). In their study, Karakuyu and Tüysüz (2011) have studied the effectiveness of conceptual change texts, and touched upon the significant role of concept maps in meaningful learning. Finally, they have concluded that conceptual change strategies affect students' academic success in a positive way.

Concept maps are graphs that show the relationship between one single concept and the other concepts in the same category. That is to say, a concept map is a two-dimensional schema illustrating the mutual correlations between the concepts under a much broader category (Kaptan, 1999:108). Concept maps rely on Novak's approach. When analyzed structure-wise, it can bee seen that they are a way of expressing interconceptual relationships in graphics. Concept maps are highly preferred by teachers as they help students to learn concepts in a meaningful way, relate their old knowledge to the new one, and most important of all, prevent misunderstandings that lead to misconceptions.

Students integrate old and new information, interpret it in their minds, and then organize it. With concept mapping method, students can show the correlation between old and new information, and so identify the relationships. Concept maps are schemas that show how information is organized. Thus, they allow meaningful learning. When the studies in teaching physics are observed, the practicality and reliability of concept maps can be clearly seen. Improving students' critical thinking skills is a very effective method used for both revealing their misconceptions and overcoming them.

Concept Cartoons

One of the most valuable methods used for structuring a piece of information visually is concept cartoons. In concept cartoons, in speech bubbles, we see people discussing daily happenings or problems. In one of the bubbles we read a scientifically accepted view; whereas, in the other one we read about a misconception. That is, concept cartoons represent misconceptions that come from life experience as well as scientific truths. When this method is applied in classes, students are expected to discuss what those cartoon characters claim, and then they make it clear who they agree with and try to agree on a solid reason for why they agree with that character.

On the other hand, some scholars criticize concept cartoons with regards to their inability to probe the subject matter as they include a limited number of words.

Concept cartoons are used both for disclosing students' misconceptions and dealing with them. Depending on the surveys, one can say that those cartoons lead to in-class discussions which in turn motivate students to participate more in classes. In this way, they have fun and are more willing to learn. Uğurel and Moralı (2006) state that cartoons, which make use of humour in a very effective way, have a critical role in learning and teaching, especially when their psychological effects are considered. Keogh and Naylor (1999) add that cartoons make people laugh; whereas, concept cartoons are rather used to encourage students to question how much they know while having fun.

It has recently been understood how important cartoons are when teaching science (Dalacosta et al, 2009). The literature has some surveys about the effectiveness of concept cartoons (Keogh and Naylor, 2000; Parkinson, 2002; Stephenson and Warwick, 2002; Coll, France and Taylor, 2005; Koch, 2010; Şengül and Üner, 2010). Researchers have developed concept cartoons rather to make learners become aware of their views concerning physics concepts and help them understand scientific facts.

The studies also discuss that concept cartoons must be drawn in a way to get rid of those misconceptions. Furthermore, the ideas of both characters in the cartoon should equally trigger scientific conflict. A concept cartoon that would definitely attract the attention of students is one that is about daily life. In the light of all the research done so far, it has been conluded that if drawn appropriately, concept cartoons, which are visual stimuli, help to overcome misconceptions.

Mind maps

Mind maps were first designed by Tony Buzan in the 1970s. Just like concept mapping, mind mapping is another technique based on students' understanding and interpretation (D'Antoni, Zipp and Olson, 2009).

To prepare a mind map, an idea or a concept is drawn in the center of paper. Then, it is circled. The total number of words to describe that concept must be as few as possible. The symbols and pictures in those mind maps stimulate a specific part of the brain about learning, and as a result, this boosts the learning process (Sprenger, 1999).

When structuring a piece of information, a mind map is the tool where students feel the most independent. Unfortunately, concept maps and mind maps are often confused. Different from concept maps, with mind maps, learners are able to remember not only concepts, but also information and ideas very well. As mind maps are shaped by the association the concept makes in learners' minds, it facilitates the memorability of the information put down on the paper. In his study on the differences between concept maps and mind maps, Budd (2004) explains that the main concept is put at the top of the page in a concept map, and various subconcepts are connected to the bottom of the map. Whereas, in mind maps, there are branches coming out of the center of the page. Colors and visuals can be used in concept maps, but in a mind map, these are much more stressed.

There are several studies analyzing the efficiency of mind maps in teaching physics (Eppler, 2006; Akınoğlu and Yaşar, 2007; AbiEl-Mona and Abd-El-Khalick, 2008; Bütüner and Gür, 2008). In a broad sense, the results prove that any information learnt through mind maps becomes absolutely permanent as there are pointers on them, guiding the brain. In addition, mind maps can also be used during the warm up of a class to find out what that concept means to students. They can categorize their opinions and concepts by relating the information learnt to the mind map. When we look at the bigger picture, we can say that mind maps definitely encourage active learning.

Analogies

Like almost in every field, analogies are one of the most commonly used methods to overcome misconceptions when teaching physics. Analogy can be defined as explaining an unknown phenomenon by means of a known or similar phenomenon. In this case, the known phenomenon is described as the source; whereas, the unknown one is the target. To reach the target, we associate to the available sources. In this sense, while comparing the unknown with the known when making analogies, it is essential to clarify how and why those similarities have been found (Küçükturan, 2003).

Duru (2002), in her survey, states that most educators have explained the significance of using analogies in teaching physics in various ways. They agree that analogies facilitate learning, make it more meaningful, and is very effective in correcting mislearning. Using analogies also allows for new questions about the topic, and realizing that the old information is not sufficient. Analogies, whenever used dynamically, have increased their knowledge about concepts. The students who wanted to clarify the issue have produced new meaningful problems about the topic by making use of analogies. In this way, the students' previous knowledge, which they have difficulty in remembering, would be called forth.

The use of analogies is helpful for learning concepts, and facilitates learning process. We learn by adding on to the old knowledge and step-by-step, because the new concept is almost always related to the old information. In this fashion, analogies are very precious learning tools. Analogue and target situation are symmetrical, so they may exchange roles. Everytime they are used, analogue and target situation are developed more (Treagust et al, 1992).

Physics educators have benefited from analogies which is a conceptual change approach (Brown,1994; Kaptan and Arslan, 2002; Yerrick et al, 2003; Oliva, Azcarate and Navarrete, 2007). The literature has proven that the use of analogies has boosted students' active participation in classes. This approach has improved students' creativity as well as their problem-solving skills, and thus has made their knowledge permanent. Analogies, which materialize abstract concepts, contribute to student-centered education by helping to create an active learning environment.

FINDINGS AND DISCUSSION

The researches conducted on teaching physics mostly focus on spotting misconceptions. However, after doing that, those misconceptions must be overcome. Hence, replacing students' old and wrong concepts with the new and right ones becomes crucial. In the light of all those studies, the conceptual change approach is believed to be very effective.

It has been agreed that, when conceptual change approach is compared with the traditional one, the former is much more powerful. When designing the new curriculum of physics courses for secondary schools, constructivism approach has been adopted. Plus, "Conceptual Change Approach" is also a very effective method for achieving the objectives. Benefiting from these two approaches will definitely increase student-teacher interaction, and in return, physics classes where they learn a lot of abstract and complicated concepts will become more fruitful for students. Thanks to that discussion environment, classes become more learner-centered.

When compared with the traditional methods, "Conceptual Change Aprroach", which has gained more importance in recent years, is a much better alternative to deal with misconception problems. As a summary of the findings from the literature review, onecan say that conceptual change texts are very efficient in diagnosing and overcoming students' misconception problems has been proved by several research. In line with those findings, there is a significant discrepancy in the rate of students' academic success in classes where they had in-class activities with mind maps and concept maps, and the ones where they had traditional classes. It has been observed that concept cartoons are much more effective on success when supported with various techniques, instruments or environments. It has been agreed that the physics activities where theachers made use of concept cartoons and mind maps has led to an increase in students' both academic success and their enthusiasm to think critically and question the information. What is more, the findings have also verified that the use of those techniques have also improved their creativity, problem-solving skills and motivation. About another visual aid, analogies, it has been realized that they develop students' guessing abilities, and enable them to understand that scientific explanations may be temporary and are sometimes subject to change.

Considering the consequences of all these researches, we would like to make some suggestions wishing that it might help with future studies:

- Teachers should be aware of the possibility that students have some misconceptions, and their previous knowledge might be wrong. They should also diagnose the reasons for the misinformation. Educators must be briefed about the significance of conceptual change texts and how to make use of them so that they can prepare their lesson plans accordingly.

- The conceptual change materials to be prepared should be eligible, present alternative perspectives, and bring the previous knowledge and ideas into light.
- When the literature on teaching physics has been reviewed, it has been noticed that there are not enough number of studies on concept cartoons and mind maps. On the other hand, there are more number of studies on conceptual change texts. Yet, the problem is that those studies are usually at elementary school level. That is why aforementioned activities for teaching physics should be conducted at all different grades.
- In accordance with the findings, it has been agreed that all those conceptual change strategies have a direct and positive influence on students' academic success and creativity. Hence, they should be applied to classes more often.
- Concept maps and concept cartoons should be incorporated into the coursebooks at secondary school levels. This will make learning much more meaningful for students.
- Teachers should receive in-service training on conceptual change strategies. In addition to this, prospective teachers in faculties of education should practise these strategies in methodology classes.

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