International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 11 ISSN 1309-6249

DETERMINING PROSPECTIVE SCIENCE TEACHERS' ASSOCIATION LEVELS OF ELECTRICITY CONCEPTS

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ABSTRACT

Science teachers should know basic science concepts and associations between them in terms of successful concept instruction. It is also important for prospective science teachers to know these basic concepts and associate them properly. In this research, it is aimed to determine associations of electricity concepts taking part in science and technology curriculums by prospective science teachers; teachers in a near future. Basic concepts partaking in the unit of 'Electricity in Our Life' were designated and it was asked for 3rd class students (n=55) studied in Science Teaching Program at Karadeniz Technical University to prepare a concept map by using these concepts. Associations were written as a text and classified by researchers as false, partly true and meaningless. It is seen that participants have difficulties in association of electricity concepts, use some alternative concepts, do not associate all of the given concepts and add associations about some concepts that were not given. It is suggested that teachers and lecturers should use these concepts carefully, direct students to accurate sources; develop concept association oriented materials and implement them.

Key Words: Prospective science teachers, electricity concepts, association.

INTRODUCTION

Innovations emerge at science brings the innovations at technology itself (Ayas and Özmen, 2002). For this reason, it is increasing day by day that students should learn about science and technology. It is not possible to teach all of this knowledge to students therefore, science education should be made effectively at conceptual level (Özmen, 2005). Students should know basic concepts and the ways of reaching needed knowledge in order to interpret the innovations at science and technology. Hence, it is emphasized the importance of teaching basic concepts and ways of reaching knowledge (Koray, Özdemir and Tatar, 2005).

Researches in recent years made at science education centre on how science concepts are perceived by students (Sencer and Eryılmaz, 2002). As a result of these studies, it was generally determined that students do not associate some concepts to scientific realities and they have great number of misconceptions at physics lessons, especially about electricity concepts (Çıldır and Şen, 2006). The subject of electricity is one of the basic areas that maintains its importance at all levels of physics instruction. At primary level, students experience

simple electric circuits, they learn electricity subject systematically in the following stages (Duit and Rhöneck, 1997; Suchai and Thasaneeya, 2012). There is an increasing view between teachers about instruction of electricity concepts and the difficulty of nature of physics knowledge (Gunstone, Mulhall and McKittrick, 2009). Many studies searching students' misconceptions about electricity concepts and learning difficulties indicate that students have difficulties in understanding electric current (Aykutlu and Şen, 2011; Aykutlu and Şen, 2012; Carlton, 1999; Duit and Rhöneck 1997; Gunstone et al., 2009; Karakuyu and Tüysüz, 2011; Küçüközer and Demirci, 2005; Küçüközer and Kocakülah, 2007; Mioković, Ganzberger and Radolić, 2012; Mulhall, McKittrick and Gunstone, 2001; Sencer and Eryılmaz, 2002; Şen and Aykutlu, 2008; Turgut, Gürbüz and Turgut, 2011; Yıldırım, Yalçın and Şensoy, 2008). Before formal education for all age levels of learners, readability of electric current is frequently affected by the words (e.g. power, current, voltage) that conflicts between physic concepts and daily life use. This conflict can rarely be changed by traditional instructional strategies. The studies about electricity misconceptions designate that there are two underlying reasons that causes concerns about this subject. Firstly, electricity, in some forms, is seen as a centre area at all levels of physics/science curriculums. Secondly, electric concepts are difficult to understand. Understanding these highly abstract and complex concepts depends on analogies and metaphors (Mulhall et al., 2001).

Concepts are the most important knowledge forms in thinking process as they are mental thinking tools that provide both understanding physical and social world and communicating (Sisovic and Bojovic, 2000). Concepts which are seen as a knowledge form and a learning product are categories used for grouping objects and events according to their common and changeable properties (Acat, 2003:170). Concept can be also defined as regularity at objects and events and it is indicated by a label. These labels can be a word, word groups or symbols (Novak and Cañas, 2006). Misunderstanding of basic concepts by students in the process of constructing knowledge affects learning advanced level concepts. This situation causes students to have difficulties in associating previous and new knowledge (Canpolat and Pınarbaşı, 2012). Determining misconceptions of students gives opportunity to teachers to gain an understanding about how students perceive a concept and to prepare a learning environment that can remove learning difficulties (Suchai and Thasaneeya, 2012). Effective science education can occur by approaching scientific knowledge at concept level which serves to classify and organize learnt (Ayvacı and Devecioğlu, 2002: 62; Koray et al., 2005). Knowledge can be learnt by associating previous and new ones. While teaching a scientific knowledge teaching concepts included by knowledge and associations between concepts enables learning. For this reason it is important associating concepts at teaching process (Acat, 2003; Ayas, 2007; Canpolat and Pınarbaşı, 2012).

Concept mapping, prediction-observation-explanation, interviews about instances and events, interviewing about concepts, drawings, and word association are some techniques used for determining misconceptions (Ayas, 2007; Özmen, 2005; White and Gunstone, 1992). In this study, it is focused on concept mapping among given techniques. Concept maps are graphical tools used for organizing and presenting knowledge (Novak and Cañas, 2006). A concept map reveals an individual's structural knowledge about a concept or subject (Zele, Lenaerts and Wieme, 2004) and aims to indicate how individuals see relations between objects, thoughts and people (White and Gunstone, 1992: 15). In a study that was made on association of concepts by concepts maps, it was designated that there are four intended purpose of concept maps as teaching, learning, planning and assessing readability of scientific concepts (Novak and Gowin, 1984 cited by Taşkın Can, Yaşadı, Sönmezer and Kesercioğlu, 2006). Besides using concept maps as a tool of teaching, while researching students' cognitive structures they are valid and reliable tools in terms of reifying associations between concepts (Atasoy, 2002) and they are used as an alternative assessment tool (Barertholz and Tamir, 1992; Kalaycı and Çakmak, 2000; Karakuyu and Tüysüz, 2011; Şen and Aykutlu, 2008). There are studies in literature about importance of concept maps in science education (Karamustafaoğlu, Ayas and Coştu, 2002), using concept maps in teaching process (Ayvacı and Devecioğlu, 2002; Çakmak, Gürbüz and Kaplan, 2012); Duru and Gürdal, 2002; Kalaycı and Çakmak, 2000; Šket, 2005; Taşkın Can et al., 2006; Türkmen, Çardak and Dikmenli, 2005; Üce and Sarıçayır, 2002) and using concept maps as an assessment tool (Barertholz and Tamir, 1992; Gemici, Küçüközer and Mergen Kocakülah, 2002; Kandil İngeç, 2008; Kaya, 2003; Şahin, 2002; Şen and Aykutlu, 2008).

When these studies are analyzed, the existence of conflicted ideas and beliefs with scientific realities can be seen at all levels and all age groups (Özmen, 2005). Anywhere in the world, students of all ages have

misconceptions about basic science concepts. It is possible to remove these misconceptions by well educated teachers who do not have any misconceptions. For this reason, it is important to determine whether prospective teachers have misconceptions or not (Aydın and Altuk, 2013; Sarıkaya, 2007). If prospective teachers do not gain understanding about basic concepts, later on it will affect their students negatively (Haidar, 1997). Therefore, prospective teachers' possible misconceptions should be determined and teacher educators should be aware of these misconceptions (Aydın and Altuk, 2013). Within this context, prospective science teachers were chosen and concept maps were used as an assessment tool. In this study it is aimed to determine prospective science teachers' association levels of electricity concepts taking part in science and technology curriculums via concept maps formed by themselves.

METHOD

Information about participants, data collection tools, data collection process and data analyze are taking part in this section.

Participants

According to the aim of the research participants consists of 55, 3rd class prospective science teachers who are studying at Karadeniz Technical University in 2011-2012 academic year and know how to make a concept map**.**

Data Collection Tools and Process

Concept maps which are effective at determining students' valid and invalid thoughts (Novak and Canas, 2006) were used as a data collection tool. Generally, concepts used for forming concept maps are chosen from curriculums, class notes, lesson notes and other sources taking part in classroom (Atasoy, 2004). In this study, acquirements and concepts about the unit 'Electricity in Our Life' taking part in the 6th, 7th and 8th class science curriculums were investigated and 51 concepts (electrical energy, conductor, non conductor, solid conductor, metals, solid non conductor, liquid conductor, solutions, liquid non conductor, electrical conductivity, brightness of the bulb, length, cross-sectional area, kind, resistance, ohm, ohmmeter, electrification, electric charge, positive, negative, neutral, electrification by touching, charge imbalance, electroscope, grounding, electrification by effect, electric current, generator, positive pole, negative pole, ampermeter, voltmeter, electrical energy sources, connection in series, connection in parallel, bobbin, magnet, electromagnet, magnetic effect, number of turn, motional energy, heat energy, heat, electrical fuse, light energy, electrical power and electrical devices) were designated. Concepts were given to students and they were asked to prepare a concept map in a period by using these concepts. Students were not informed about concept maps as they have already known.

Data Analysis

Scoring methods of concept maps can be classified as quantitative and qualitative methods (Zele et al., 2004). Intended purpose of concept maps is important in determining analyze method of collected data (Şen and Koca, 2003). Quantitative analyzing methods are appropriate for investigating learning process in mental structure and revealing personal differences whereas qualitative analyzing methods are appropriate for confirming previous knowledge and learning difficulties. In this study data collected by concept maps were converted into text in the manner indicating associations between two concepts. Descriptive analysis is used for data analysis. Two physics teachers' opinions were taken during analysis. Inappropriate association words or additions may refer partly true or false understandings therefore researchers took cognizance of associations and additions. In studies searching associations between concepts, data were classified as understanding, misunderstanding, not understanding and irresponsiveness (Ayas and Özmen, 2002); true, false, acceptable and meaningless (Aykutlu and Şen, 2008; Çıldır and Şen, 2006); true, partial misconception, misconception, unanswered, not being able to associate (Kalın and Arıkıl, 2010). In this study associations were classified as false, partly true and meaningless. Definitions of classifications are indicated below:

False association: There is a false association between two related concepts or concepts which have no relations are associated.

Partly true association: Inappropriate associations between two related concepts, far or indirect associations between related concepts

Meaningless association: Associations have no meanings when converted into text.

FINDINGS

Categories related to associations were determined according to the definitions given in data analysis part. Associations representing same relations and associations stated by more than one student were shown in tables.

Students' false associations about electricity concepts and frequency of these associations were given in Table 1.

Table 1: False associations

Associations	f
Positive, negative and neutral are types of electricity charges	24
Electrical conductivity is supplied by electrification	6
Grounding is a type of electrification	4
Magnet has positive/negative poles	3
Bobbin/magnet are examples of electrical devices	3
Electromagnet is an example of electrical devices	2
Electrification by magnet is a type of electrification	2
Electrification by touching creates positive/negative pole	2
Metals are sorted as conductor/non conductor	2
Resistance is inversely proportional to electric current	2
Resistance creates voltage	2

According to Table 1, 24 students have false associations about types of electricity charges. Students think that electricity charges are sorted as positive, negative and neutral. Being neutral is not considered as the balance of positive and negative charges.

6 students falsely associated electrical conductivity to electrification concepts. They think that electrical conductivity is a result of electrification. Another false association is about poles of magnet. 3 students consider that magnet has two poles called as positive and negative. Whereas 3 students think that magnet is an electrical device, another 2 students describe electromagnet as an electrical device. 8 students have false associations about electrification. Whereas 2 of them think that electrification by magnet is a type of electrification, 4 of them think that grounding is a type of electrification. 2 students think that electrification by touching creates positive and negative poles. 2 students think that metals are sorted as conductor and non conductor.

Another false association is about 'Ohm's Law'. 2 students think that resistance -independently of conductor- is inversely proportional to electric current. Finally, 2 students falsely associated resistance to voltage. They think that resistance creates voltage in an electric circuit.

Students' partly true associations about electricity concepts and frequency of these associations were given in Table 2.

Table 2: Partly true associations

Associations	f
Electric energy is related to electrification	14
Electric current creates magnetic effect	6
Non-conductor does not conduct electricity	6
Conductor conducts electricity	5
Electric current is formed by electric charges	5
Electric current is conducted by electrification	3
Electrification is formed by electric charges	2
Electric creates magnetic effect	2
Electrification causes electricity	2
Electrical conductivity is not conducted by non conductor	2
Electrical conductivity is conducted by conductor	2
Electrical devices works with electrical power	2
Electrical current creates magnet	2
Electric energy is formed by electric charges	2
Electric energy is produced by electricity	2
Electrical conductivity depends on resistance	2
Motional energy/light energy/heat energy are types of electric energy	2
Bobbin/magnet/electromagnet produces magnetic effect	2
Electrification is formed by electric current	2
Resistance is a react to electric energy	2
Generator is formed by positive/negative poles	2

Partly true associations in Table 2 come under three themes as associations not expressed clearly, associations with alternative concepts and far associations. These themes are presented below.

Associations not expressed clearly

As shown in Table 2, 14 students associated electrification to electrical energy partly true. Students used different words that have same meaning in relating concepts but they did not express clearly what kind of electrical energy will be created by electrification and they did not mention that energy is electrical potential energy.

6 students associated electric current to magnetic effect. Students are of one mind that electric current creates a magnetic effect but they did not mention that electric charges' motion is the source of magnetic effect.

4 students associated conductor and non conductor to electrical conductivity. 2 students defined non conductor as not conducting electrical conductivity, 2 students defined conductor as conducting electrical conductivity.

5 students associated electric current to electric charges. Students stated that electric charges create electric current but they did not mention which aspects of electric charges create electric current. There is an association between electric charges and electrical energy indicated by 2 students. They stated that electric charges may create electrical energy without mentioning how it happens.

Another two concepts that students try to associate are electrical conductivity and resistance. 2 students stated that these concepts are related to each other without mentioning what kind of relation it is. They did not write how electrical conductivity will be affected in case resistance increase or decrease.

When associations between electric energy and other energy types are taken into account, it is seen that 2 students thought that light, heat and motional energy are types of electrical energy. These concepts have a relation but this relation should be 'electrical energy transforms into light, heat and motional energy'.

Bobbin, magnet and electromagnet are the other concepts associated to magnetic effect. 2 students indicated that bobbin, magnet and electromagnet may create magnetic effect but they did not give place to how this effect will occur.

Associations with alternative concepts

17 students made associations using electric concept instead of electrical energy or electric current concepts. 6 of them indicated that non conductors do not conduct electrical energy or electric current, whereas 5 of them indicated that conductors conduct electrical energy or electric current by using only electricity concept. 2 students used electricity concept while stating electric current may create magnetic effect. 2 students both used electricity concept and made far association in regard to electrification causes electric current. 2 of them could not express relation between concepts well enough in spite of they used concepts properly. Finally, 2 students chose electric concept instead of electric current while they were indicating that electric current produces electrical energy.

Far associations

2 students associated electric power to electrical devices. They indicated that electrical devices use or work with electrical power.

There is an association between electric current and magnet stated by 2 students. Students mentioned that a magnet can be derived from electric current but there is no direct relation between these concepts.

Students' meaningless associations about electricity concepts and frequency of these associations were given in Table 3.

Table 3: Meaningless associations

Associations	f
Ohm meter is related to voltmeter	2
Electricity creates electric current	2
Electrical energy sources creates resistance	2

According to Table 3, there are 3 different meaningless associations indicated by 6 students. 2 of them mentioned that ohmmeter and voltmeter have a relation. 2 students stated that electric may create electric current. Finally, 2 students associated electrical energy sources to resistance. They stated that resistance is created by electrical energy sources.

DISCUSSION AND CONCLUSION

Prospective science teachers' association levels of electricity concepts were determined via concept maps in this study. Generally, prospective science teachers have difficulties in associating electricity concepts, they do not associate all of the concepts given and they add some concepts to associations that were not given. According to the findings, discussion, conclusion and suggestions were given below in detail.

It is determined that prospective science teachers' false associations were mostly about electrification taking part in electrostatics unit. In a research Kurnaz, Tarakçı, Saydam and Pektaş (2013) aimed to reveal secondary school students' mental models about electrification, thunderbolt and lightning. They precipitated that students have some non scientific knowledge about these concepts. However, it is seen that prospective science teachers could not express the relation between electrostatics and flowing electricity clearly. They did not articulate the relation between electrification and electrical energy or electric current. Electrostatics as a subject is firstly taught at primary level. It is precipitated that electrostatics and electric circuits are seen as independent subjects at a research made with university students in France and Sweden (Rainson, Tranströmer and Viennot, 1994). This may be rooted in previous knowledge of students or studied materials before. Moreau & Ryan (1985) stated that the relation between electrostatics and electric circuits is given superficially or not

touched in many textbooks. Ünsal and Güneş (2002) made an argumentative research about 4. class science textbook in terms of physics subjects. They expressed that electrification subject taking part in electricity unit should be changed otherwise it will ground students' misconceptions. However, according to researchers, it will be hard to remove the thought that 'statics' and 'current' states opposite points. Therefore, it is suggested that materials should be prepared by not permitting misconceptions.

It is seen that some prospective science teachers have difficulties in interpreting mathematical formula of Ohm' Law. They think that resistance will be decrease if electric current increases or resistance will increase if voltage increases. There are similar findings about Ohm's Law in literature (Afra, 2009; Çıldır, 2005; Duit and Rhöneck, 1997; Periago, 2005; Picciarelli, Di Gennaro, Stella and Conte, 1991). In a study made by using concept maps with 244 secondary school students, it is determined that there are false associations between resistance and electric current or voltage. Students' not understanding Ohm's Law literally and perceiving this law as a simple mathematical formula may cause this misconception (Çıldır, 2005). Students think that resistance depends on electric current or voltage rather than it is a property of conductor. This way of thinking may be also a source of this misconception. Another study carried out with 12 students at the age of 14-15 revealed that students failed at understanding that resistance is a property of conductor's itself. Students have a misconception as 'If there is not electric current there will be no resistance' (Afra, 2009). Prospective science teachers have similar misconceptions with the indicated 14-15 aged students and that may arise from maintained misconceptions of prospective science teachers. Teachers and lecturers should not give only mathematical formula of Ohm's Law, they should express it qualitatively and examine in detail to remove this kind of misconceptions (Periago, 2005).

It is seen that some prospective science teachers can not comprehend electricity, electric current and electrical energy literally. Prospective teachers sometimes use these concepts interchangeable whereas sometimes they associate them each other. These results are in compliance with the results of researches made by Çıldır (2005) and Cheng and Kwen'in (1998). Abstract nature of electricity, usage in daily life and mistakes made by teachers about electricity subject may cause students not to comprehend these concepts (Çıldır, 2005). Quantity of electric charges, quantity of energy, electrical potential, force, field, net charge, current or power can be mentioned by the word 'electricity'. Trying to mention all of these concepts with one word may complicate electricity subject (Ünsal and Güneş, 2002). It is important to indicate the difference between scientific meaning and daily meaning of these concepts for preventing misconceptions. Definitions which are in accord with scientific realities should be given during the instruction of these concepts.

As distinct from literature, prospective science teachers have a misconception in regard to electric charges have three types. They think being neutral is another type of electric charges rather than balance of positive and negative charges. Usage of these three concepts generally together may cause this misconception. The misconception 'magnet has positive and negative poles' is taking part in literature as 'south and north magnetic poles are the same as positive and negative charges' (Barrow, 2000).

It is seen that prospective science teachers could not associate basic concepts that should be known well as conductor and non conductor. However, they know that there is a relation between electricity and magnetism concepts but they could not articulate this relation. Demirci and Çirkinoğlu (2004) aimed to determine misconceptions and previous knowledge of university students about electricity and magnetism concepts. As a result of the study it was found that students have problems about charge distribution of conductors and non conductors and also they have misconceptions about electricity and magnetism.

Some prospective science teachers did not use all of the concepts given while preparing concept maps. Unassociated concepts are differing from each student. Some prospective science teachers added certain concepts that were not given. These concepts taking part in concept maps are 'energy, heat and frictional electrification'. Students' previous knowledge about these concepts and the related concepts may cause these adding.

International Journal on New Trends in Education and Their Implications
January 2014 Volume: 5 Issue: 1 Article: 11 ISSN 1309-6249

IJONTE's Note: This article was presented at World Conference on Educational and Instructional Studies – WCEIS 07- 09 November, 2013, Antalya-Turkey and was selected for publication for Volume 5 Number 1 of IJONTE 2014 by IJONTE Scientific Committee.

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