The effect of electric current teaching based upon the 5E model on academic achievement and attitudes of students

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Received 18 Mar., 2016
Revised 15 Nov., 2017

Contents

Abstract

In this research, the purpose was to examine and compare the effect of teaching Electric Current, which is a topic of grade 11 physics lesson, on student achievement and attitude according to the 5E model belonging to the constructivist learning theory and the traditional teaching method. The research was conducted in the spring semester of 2009-2010 academic year with 62 students who were attending the 11th grade. The quasi-experimental method was used in the research and the significance level was p=0.05. A meaningful difference (p<0.05) was

observed on behalf of the experimental group according to the results of the independent samples t-test related to the post-test scores of "Electric Current Achievement Test (ECAT)" of the students in the experimental and control groups. It was concluded that the worksheets applied, cartoons, animation and laboratory activities used while teaching the topic "Electric Current" according to the 5E model provided better understanding by students, increased the motivation related to the lesson, created a positive effect on understanding abstract concepts. The results of the attitude scale showed that the differences between the groups were insignificant ($p>0.05$).

Keywords: 5E Model, Constructivist Learning, Electric, Attitude

Introduction

The developments in science and technology shape almost every phase of our social lives. Science is a field in which the base of science and technology is taught. By the help of science lessons, individuals are developed in terms of cognition and productivity. Thus, modern theories must be applied in the teaching of science (Isman, Baytekin, Balkan, & Horzum, 2002).

Today, the most important purpose of reforms related to education is to provide a system which would help students learn with understanding. In order to manage this, it is agreed that it is necessary to apply new methods through learning and teaching approaches in which prior knowledge of students are considered and students reach the information on their own- that is to say that students actively engaged in learning process and take responsibilities in learning. Contemporary approaches emphasize a student-centered teaching which takes student learning as the base by considering individual differences of students and learning characteristics of students. The effectiveness of the constructivist learning theory, which is one of these approaches, has increased recently. It is seen that secondary education physics curriculum is being developed again according to modern learning theories and approaches and the constructivist approach is adopted in the studies of curriculum particularly. As the reasons of this, it is possible to say that it advocates a student-centered learning and tries to provide a learning environment which would contribute to increasing high-level student motivation and thinking skills (Boddy, Watson, & Aubusson, 2003).

Teachers in many countries, especially in developed countries, are welcoming an educational understanding which is based on the constructivist approach with open arms (Powell, Farrar, & Cohen, 1985). The constructivist approach depends on the notion that knowledge is better learnt in consequence of actively structuring by the individual. The main structure of this opinion depends on establishing a connection between current information and prior knowledge in order to provide learning. In constructivist classes, students are encouraged to hypothesize and test these hypotheses. They do not receive the explanations made by teachers passively. They acquire the necessary skills to apply what they have learnt to other problems (Limon, 2001; Smerdon, Burkam, & Lee, 1999).

In constructivist student-centered classrooms, mental energy of a student is high in most of a lesson. The mental energy of a teacher is also high because s/he guides students during lesson as they structure information. The increase in students' interest increases teachers' efforts. A more productive and enjoyable learning environment is provided. An ideal learning environment increases involvement, critical thinking and permanence of knowledge(Lord, 1999). Students may check their own learning (Brooks & Brooks, 1999; Kanselaar, 2002; Salomon, 1999).

Osborne and Wittrock (1983) who are among the supporters of the constructivist approach and practitioners of it in Science Education emphasize that the accumulation of knowledge that a student or an individual possess at any time is very important in responding new information or stimulus (Burhberger, 2000; Lewis, 2001; Sensoy, Yildirim, & Aydogdu, 2006).

Different learning and teaching models have been developed for the sake of using the constructivist learning approach. One of these models which have been carried out recently with different process phases in the education process is the 5E learning model. The 5E model is a science teaching method, depending on research-based constructivist learning theory and experimental activities. This model was developed by Bybee (1993), who is one of the leading names of Biological Science Curriculum Study (BSCS), in 1967 and used (MMS., 2002). In the researches conducted on the 5E model, there are findings which support the idea that the model increases achievement of students, provides their conceptual development and changes their attitudes in a positive way (Kor Ayas, 2006; Saglam, 2006).

The 5E model has been built on the results of researches that are determined within the standards of national science education (Newby, 2004). The model consists of 5 phases; Engage-Enter, Explore, Explain, Elaborate and Evaluate (Carin & Bass, 2005). The 5E model enables to learn a new concept or understand a well-known concept thoroughly (Ergin, Kanlı, & Tan, 2006).

In our country, various activities and materials have been developed according to the constructivist learning theory (Cepni, Akdeniz, & Keser, 2000; Gurses, 2006; Ozmen & Yildirim, 2005; Sifoglu, 2007). These developed activities and materials are generally prepared in accordance with the 5E model. It has been expressed that this is the model whose usability is the highest (Gurses, 2006). As a result of the review made in the literature, it has been observed that most of the materials prepared according to the 5E model are in accordance with all stages of the model and equal emphasis is focused on each stage (Er Nas, Cepni, Yildirim, & Senel, 2007; Gurses, 2006; Orgill & Thomas, 2007).

It is known that students in many conducted researches could not easily learn physics concepts, which are artificial, and they made mistakes in these concepts (Cepni, 1997; Eryilmaz, 2002; Kucukozer, 2004). Karacam and Digilli Baran (2015) stated that physics achievements of students having a social oriented motivation are low, since physics teaching environments does not support social learners.

Teaching of the topic electricity through the 5E model of the constructivist approach and researching the effect of this model on the academic success and attitudes of students would be important to provide effective, permanent and meaningful learning.

Purpose

The purpose of this research is to search the effect of teaching the topic Electric Current, which is taught in the content of 11th grade physics lesson, according to the 5E model of the constructivist learning theory and the traditional method on academic achievement and attitudes of students.

Method

The quasi-experimental method was employed in this research. The research has pretest-posttest design with experimental and control groups. This method appoints

the sample to the groups randomly and determines the groups (Cepni, 2010). The application was carried out in both experimental and control groups by the researcher.

Participants

The study population of the research consisted of 62 grade 11 students attending high school in the second semester of 2009-2010 academic year. The control group included 33 students and the experimental group included 29 students. These students were selected according to the random sampling rule.
Group and individual differences of students in both groups were minimized before starting the application by means of random appointment.

Data Collection Tools

In this research, Electric Current Achievement Test (ECAT), Science Attitude Scale were used as data collection tools.

Achievement Test

The achievement test which was used to determine the effect of the 5E model, suggested for the constructivist learning theory on academic achievement of students, was prepared by asking experts' opinions. A test including 30 questions that match up with the attainments based on the grade 11 physics course book of the Ministry of National Education (MNE) was prepared. This test was conducted on 60 grade-12 students who studied this topic the previous year. Nine questions whose item distinguishing index was 0,19 or less were eliminated in consequence of SPSS 16.0 item analysis and the number of questions in ECAT was decreased to 21. The reliability of the test was determined as 0.863 by using Kr-20. Thus, the test which would be carried out in the experimental and control groups was obtained.

Science Attitude Scale

The science attitude scale (SAS) which was carried out before and after the application was developed by Baykul (1999) and its reliability was calculated as 0.92. This 30-item likert-type attitude scale consists of 5 degrees including "I completely agree, I agree, I am doubtful, I disagree, I never disagree" (Dalkiran & Kesercioglu, 2005).

Analysis of the Data

The data collected in the research was analyzed using SPSS 16.0 statistical package program. Independent t test was used while evaluating the scores obtained from the electric current achievement test, the attitude scale related to physics lesson; comparing the experimental and control groups with each other. Dependent t test was employed to compare the pretest and posttest scores within both groups. In both t-tests, the significance level was accepted as 0.05.

Application of the Research

The research was designed and applied in the process of 2009-2010 academic year. The research was designed according to the semi-experimental method and its application was carried out in the spring semester. The application phase of the research was carried out with 3 hours of lessons a week for 3 weeks in the experimental and control groups.

The 5E model developed by Bybee (1993) was used in the experimental group in which lessons are taught according to the computer-supported learning method which is based on the constructivist approach.

During the process of 3 hours of physics lessons per week, the students in the experimental group were divided into groups of two and three before applications. In order to provide an environment in which students would use their time productively while collaborating, they were allowed to choose their own group. Group work is a method which is effective especially in projects, collaborative learning, problem solving studies and workshops (Walker & Angela, 1998). This is appropriate for the 5E model. The purpose of dividing students into groups is to create a competition environment between the groups and encourage them help each other collaboratively.

Students in the experimental and control groups were administered the Electrical Current Success Test (ECAT) and the Lamps Luminance Success Test (LLST) as a pre-test.In order to enable the students in the experimental group to visualize the topic in their minds, increase visual richness during lessons, animations and demonstrations collected from various resources were displayed by means of computers. Besides, cartoons obtained from various resources and circuit schemas were exhibited at a location in the classroom that students could easily see during the application. Prepared worksheets and laboratory activities were applied.

In consequence of the study process, the Electric Current Achievement Test (ECAT) was applied as the posttest to both experimental and control group.

Findings

The findings obtained from the research are given below. The Electric Current Achievement Test (ECAT) pretest scores of the students of the experimental group in which the lesson was studied according to the 5E model and the students of the control group in which the lesson was taught according to the traditional teaching method were compared by using the independent t-test and the results are given in Table 1.

Table 1. Results of t-Test Related to the ECAT Pretest Scores of the Students in the Experimental and Control Groups

Measurement	N	X	Std. Dev.	df	t	p
Pretest (Control)	33	5.55	1.986	60	-.309	.758
Pretest(Experimental)	29	5.76	3.345			

As it can be seen in Table 1, there is not a meaningful difference between the pretest scores of the experimental and control groups (p= .758 >0.05). Accordingly, it is likely to say that both groups were close to each other before studying the topic.

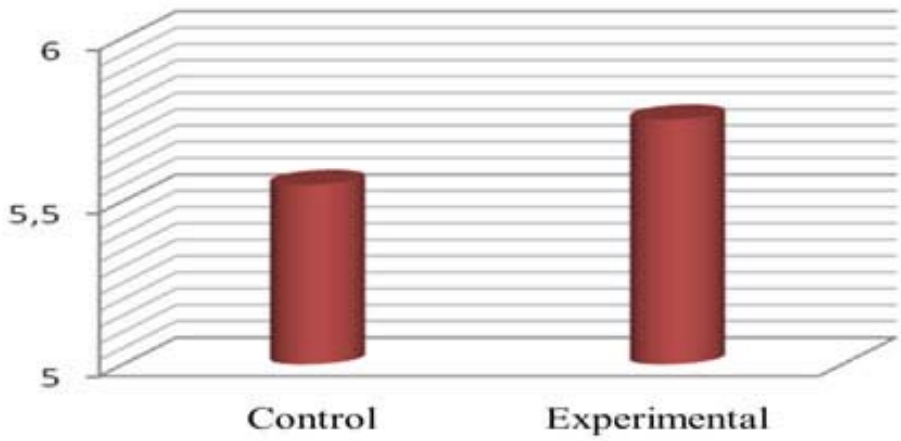

Figure 1. ECAT pretest mean value

Electric Current Achievement Test (ECAT) posttest scores of the experimental and control groups were compared by means of independent t-test and the results are given in Table 2.

Table 2. Results of the t-Test Related to the ECAT Posttest Scores of the Students in the Experimental and Control Groups

Measurement	N	X	Std. Dev.	df	t	p
Posttest (Control)	33	8.21	2.190	60	-7.150	.002
Posttest(Experimental)	29	14.07	4.088			

Table 2 shows that there is a considerable difference between the posttest scores of the control group and the experimental group (p= 002 <0.05). In the post test, the experimental group was more successful than the control group.

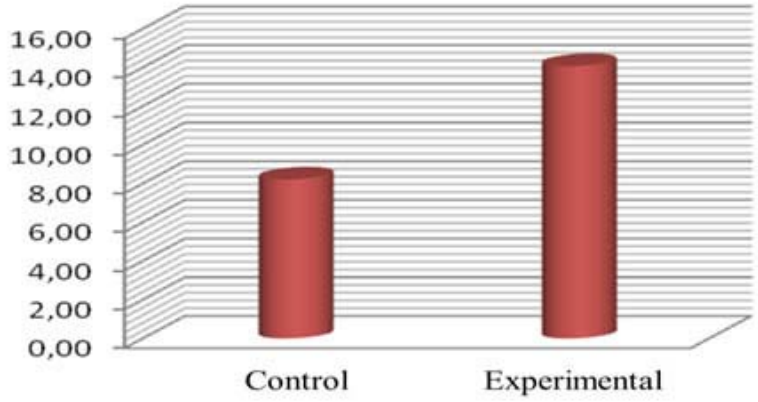

Figure 3. ECAT posttest mean values

Independent t-test analysis was conducted in order to understand whether there is a meaningful difference between the pretest and posttest scores of the students in the experimental and control groups.

Electric Current Achievement Test (ECAT) pretest and posttest scores of the students in the experimental group were compared using dependent t-test, and they were given in Table 3.

Table 3. Results of the t-Test Related to the ECAT Pretest and Posttest Scores of the Students in the Experimental Group

Measurement	N	X	Std. Dev.	df	t	p
Pretest (Experimental)	29	5.76	3.345	28	-12.019	.000
Posttest (Experimental)	29	14.07	4.088			

As it can be seen in Table 3, there is a significant difference between the pretest-posttest scores of the experimental group (p= . 000 <0.05). Students in the experimental group were more successful in the posttest in comparison with the pretest.

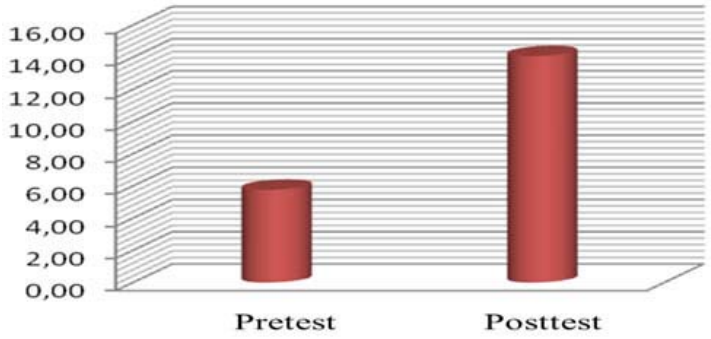

Figure 5. ECAT experimental group mean values

The results of the t-test related to ECAT pretest-posttest scores of the students in the control group are given in Table 4.

Table 4. The Results of t-Test related to the ECAT Pretest-Posttest Scores of the Students in the Control Group

Measurement	N	X	Std. Dev.	df	t	p
Pretest (Control)	33	5.55	1.986	32	-7.188	.000
Posttest(Control)	33	8.21	2.190			

When Table 4 is examined, it is seen that there is a meaningful difference between the pretest and posttest scores of the control group (p =. 000 <0.05). The control group was more successful in the posttest in comparison with the pretest.

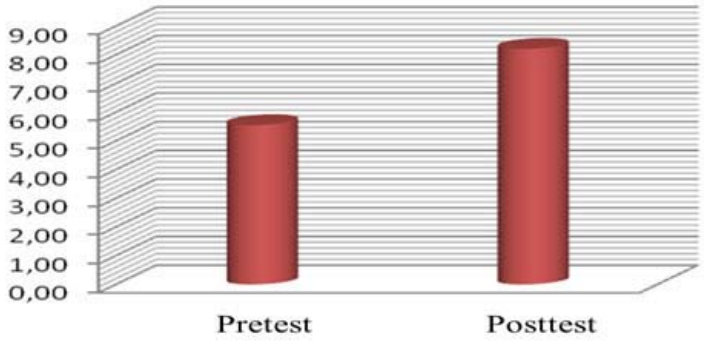

Figure 6. ECAT control group mean values

When the groups are compared, it is seen that ECAT pretest score mean of the experimental group is 5.76, pretest score mean of the control group is 5.55. Posttest score means of the experimental and control groups are 14.07 and 8.21 respectively. As it is seen here, there is not a meaningful difference between the pretest scores of the groups but there is a significant difference on behalf of the experimental group in terms of posttest scores.

The Results of the Attitude Scale

The attitude scale used in the research has 3 subfactors. These subfactors are "affection", "interest" and "importance of physics in daily life". The results of the scale were evaluated by using t-test according to these factors. The results obtained from these subfactors are given below.

Examination of "affection" subfactor

Pretest scores of the experimental and control group students related to "affection" subfactor were compared using independent t-test and the results are given in Table 5.

Table 5. Results of the t-Test related to the "Affection" Subfactor of the Students in the Experimental and Control Groups

Pretest	Groups	N	X	Std.Dev.	df	t	p
Affection	Control	33	25.33	6.392	60	1.033	.878
	Experimental	29	23.76	5.495			

According to the Table.5, there is not a significant difference between the pretest scores related to the "Affection" subfactor of the students in the experimental and control groups (p =. 878 >0.05). Posttest scores related to the "Affection" subfactor of the students in the experimental and control groups were compared by means of independent t-test and the results are displayed in Table 6.

Table 6. Results of the t-Test related to the Posttest Scores Belonging to the "Affection" Subfactor of the Student in the Experimental and Control Groups

Posttest	Groups	N	X	Std. Dev.	df	t	p
Affection	Control	33	24.36	7.176	60	.226	.738
	Experimental	29	23.97	6.598			

As it can be seen in Table 6, there is not a significant difference between groups (p>0.05). This result shows that there are no changes in the attitudes of the students in terms of "affection" subfactor.

Examination of "Interest" Subfactor

Pretest scores of the experimental and control groups related to the "Interest" subfactor were compared using independent t-test and the results are given in Table 7.

Table 7. Results of the t-Test related to the Pretest Scores Belonging to the "Interest" Subfactor of the Students in the Experimental and Control Groups

Pretest	Groups	N	X	Std. Dev.	df	t	p
Interest	Control	33	11.67	2.723	60	-1.169	.450
	Experimental	29	12.52	3.007			

According to Table 7, there is not a considerable difference between the pretest scores of the experimental and control groups related to the "Interest" subfactor of the attitude scale (p=. 450 >0.05). Posttest scores related to the "Interest" subfactor of the experimental and control groups were compared by using independent t-test and the results are given in Table 8.

Table 8. Results of the t-Test related to the Posttest Scores Belonging to the "Interest" Subfactor of the Students in the Experimental and Control Groups

Posttest	Groups	N	X	Std. Dev.	df	t	p
Interest	Control	33	11.45	2.862	60	-.837	.558
	Experimental	29	12.10	3.244			

According to Table 8, as the significance level is ($p>0.05$), there is not a meaningful difference between the groups. It is possible to say that this study could not make a meaningful difference in the attitudes of the students in terms of "interest" subfactor.

Examination of "importance of physics in daily life" subfactor

The pretest scores of the experimental and control groups related to the "importance of physics in daily life" subfactor were compared by using independent t-test and the results were given in Table 9.

Table 9. Results of the t-Test related to the Pretest Scores of the Students in the Experimental and Control Groups in terms of "importance of Physics in daily life" Subfactor

Pretest	Groups	N	X	Std. Dev.	df	t	p
Importance of Physics in	Control	33	21.94	2.715	60	2.314	.114
	Experimental	29	20.14	3.409			

When Table 9 is examined, it is seen that there is not a significant difference between the pretest scores of the experimental and control groups in terms of "importance of physics in daily life" subfactor ($p>0.05$). The posttest scores of the experimental and control groups related to the subfactor "importance of physics in daily life" were compared using independent t-test and the results are given in Table 10.

Table 10. Results of t-Test related to Posttest Scores of the Students in the Experimental and Control Groups in terms of Subfactor "Importance of Physics in Daily Life"

Posttest	Groups	N	X	Std.Dev.	df	t	p
Importance of Physics in	Control	33	22.18	3.015	60	2.144	.214
	Experimental	29	20.41	3.480			

As the significance level is ($p>0.05$) according to Table 10, no significant differences were determined between groups. It is possible to say that this study did not make any differences in student attitudes in terms of "importance of physics in daily life" subfactor.

Discussion

In this study, it was observed that there were not significant differences between the results of the ECAT pretest applied to the students in the experimental and control groups. As a result of the research, it was observed that the students in the experimental group in which the 5E model was carried out were more successful than the students in the control group. For the experimental group in which lessons were studied in accordance with the 5E model, a considerable difference was observed between the success points of ECAT which was applied before and after the application. Depending on this result, it is possible to say that lessons which are taught in accordance with the constructivist E model with computer-support and material use have a great effect on student achievement. Similar results were found in consequence of investigation in the literature (Aydogmus, 2008; Er Nas, Cepni, & Coruhlu, 2010; Ergin et al., 2006; Gurses, 2006; Hand & Treagust, 1991; Kılavuz, 2005; Ozmen, 2004; Ozsevgeç, 2007; Saglam, 2006; Saka, 2006; Wilder & Shuttleworth, 2004; Yildiz, 2008).

In the research, it was determined that the worksheets used in the lessons which were taught according to the 5E model had positive effects on understanding abstract concepts by students. The search done in the literature provided similar results obtained in this research (Gurses, 2006; Ozdemir, 2006; Ozmen & Yildirim, 2005).

In the research, it was observed that the cartoons, animations and laboratory activities which were used in lesson teaching based on the 5E model increased students' motivation towards the lesson and created positive effects on understanding abstract concepts. Similar results were found in consequence of investigation in the literature (Altun Yalcın, 2003).

In the research, it was determined that one-to-one interviews with the students and group works in the experimental group affected motivation to learn in a positive way. The search in the literature also provided similar results (Ozmen & Yildirim, 2005; Turker, 2009).

The results of the attitude scale applied in the research show that there are not significant differences in terms of attitude levels towards physics lesson between the experimental and control groups, but it was observed that the students in the experimental group were more willing and interested in the lesson during application. The search in the literature shows that there are researches having similar (Aydogmus, 2008) and contrary results-that is to say, researches show that the lessons which are studied according to the 5E model change attitudes of the students in a positive way (Akar, 2005; Balci, Cakiroglu, & Tekkaya, 2006; Boddy et al., 2003; Seyhan & Morgil, 2007; Teltik Baser, 2008; Turker, 2009) have been found.

In the research, it was seen that it is quite hard under the conditions of our country to teach all lessons through activities in which the 5E model is used. Similarly, it was determined by Sezen, Konur, and Cimer (2008)' in their research which was conducted with teachers that some subjects were not appropriate for the 5E model and the models had some problems such as being time-consuming. It was stated that preservice teachers had difficulties in the phases of the model during application, they could not establish classroom authority. Related to the students, it was observed that their prior knowledge was inadequate and they got bored of the use of the model continually. In some research, it was expressed that a lack of material was experienced while using the 5E model (Baskan, Alev, & Atasoy, 2007; Bozdogan & Altuncekic, 2007).

Other constructivist studies were encountered while searching in the literature (Ates & Polat, 2005; Cavallo, 1996; Chambers & Andre, 1997; Lawson, 2001; Marshall & Dorward, 2000; Wang & Andre, 1991). In their researches, the researchers determined that teaching methods which were developed by using

science teaching approaches and conceptual change strategies as base were more successful than the traditional teaching model in learning topics of physics. have figured out the effectiveness of an active learning based-interactive conceptual instruction (ALBICI) on pre-service physics teachers' understanding on electric field concepts. The findings suggested that ALBICI teaching model enhanced pre-service physics students' conceptual understanding and reduced most of their misconceptions despite a few misconceptions still occurred.

In this research, the effect of teaching the topic "electric current" according to the 5E model on academic achievement of students and their attitudes towards physics lesson was examined and the following results were obtained;

1. No meaningful differences were observed between the results of ECAT pretest conducted on the students in the experimental and control groups. In other words, it was determined that knowledge levels of the students in the experimental and control groups related to the topic were the same.
2. A significant difference was observed between the results of ECAT posttest applied to the students in the experimental and control groups. In consequence of the analyses, it was determined that the students in the experimental group were more successful than the students in the control group in the achievement test including the topics of Electric Current.
3. A considerable difference was observed for the experimental group in which the lesson was taught according to the constructivist 5E Model between achievement scores of ECAT test which was applied before and after the application. The results show that the students in the experimental group in which the 5E Model was carried out were more successful in the posttest, thus the model is an effective teaching method.
4. Analysis results of the attitude scale which was applied to the students before and after the application show that there is not a statistically significant difference in terms of attitudes towards physics lesson between the experimental group in which the 5E model was followed and the control group in which the traditional method was carried out.
5. The worksheets used during the teaching based on the 5E model were used to encourage students to work collaboratively, draw their attention to the lesson, and they provided benefits.

6. It was observed that one-to-one interviews with the students in the experimental group created positive changes in students' motivation and their attitudes towards the lesson.
7. It was observed that cartoons and animations provided positive effects on understanding abstract concepts.

From the findings of this study the recommendations given below can be given;

1. The 5E model should be studied for a longer time and its effect on attitudes, permanence of concept learning should be examined.
2. In order to use the constructivist approach, first of all teachers should be informed about it and training to facilitate the application for teachers and preservice teachers should be provided.
3. Preparing laboratory guide books for teachers by arranging necessary studies in this respect and providing in-service training for teachers may increase the use of laboratories.
4. It is thought that one-to-one interviews with students in the process of education would affect achievement of students in a positive way.
5. It has been observed that teaching based on the 5E model takes a long time. It is possible to use time more effectively by giving students homework for the phases of enter and evaluation.
6. It is necessary to use multimedia combining graphics, animations, simulations, sounds, colors, software and video clips in the education environment, along with real models, shapes.
7. Projects in which students can express themselves, discover their abilities, evaluate the activity that they do should be supplied for students.

References

Akar, E. (2005). *5E Ogrenme Dongusu Modelinin Ogrencilerin Asit ve Bazlarla Ilgili Kavramlari Anlamalarina Etkisi*. (Yuksek Lisans Tezi), ODTU, Ankara.

Altun Yalcın, S. (2003). Yapilandirici Ogrenme Teorisine Dayanan Laboratuvar Aktivitesi: Universite Ogrencilerine Suyun Otoprotoliz Sabiti Tayininin Ogretilmesi. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 24*(1), 125-134.

Ates, S., & Polat, M. (2005). Elektrik Devreleri Konusundaki Kavram Yanılgılarının Giderilmesinde Ögrenme Evreleri Metodunun Etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 28*, 39-47.

Aydogmus, E. (2008). *Lise 2. Sinif Ogencilerinin Enerji Konusundaki Kavram Yanilgilari ve Yapilandirmaci Ogretimde 5E Modeli ile Giderilmesi.* (Yuksek Lisans Tezi), Selcuk Universitesi, Konya.

Balci, S., Cakiroglu, J., & Tekkaya, C. (2006). Engagement, exploration, explanation, extension and evaluation (5E) learning cycle and conceptual change text as learning tools. *Biochemistry and Molecular Biology Education, 34*(3), 199-2003.

Baskan, Z., Alev, N., & Atasoy, Ş. (2007). Fen Bilgisi Öğretmen Adaylarının 5E Modelinin Uygulamaları Hakkındaki Görüşleri. *Yeditepe Üniversitesi Eğitim Fakültesi Dergisi, 2*(2).

Baykul, Y. (1999). *Istatistik: metodlar ve uygulamalar.* Ankara: Ani yayincilik.

Boddy, N., Watson, K., & Aubusson, P. (2003). A trial of the five Es: A referent model for constructivist teaching and learnıng. *Research in Science Education, 33*, 27-42.

Bozdogan, A. E., & Altuncekic, A. (2007). Fen Bilgisi Ogretmen Adaylarının 5E Ogretim Modelinin Kullanılabilirligi Hakkındaki Gorusleri. *Kastamonu Eğitim Dergisi, 15*(2), 579-590.

Brooks, M. G., & Brooks, J. G. (1999). The Courage to be Constructivist. *Educational Leadership, 57*(3), 18-24.

Burhberger, F. (2000). Active Learning in Powerful Learning Enviroment. Retrieved from http://www.pa_linz.ac.at/team/homepage/BurchbergerF/01%20FB%20Activec.pdf

Bybee, R. (1993). *Instructional model for science educationin developing biological literacy:* Colorado Springs.CO: Biological Sciences Curriculum Studies.

Carin, A., & Bass, J. (2005). *Teaching Science As Inquiry.* New Jersey: Pearson Prentice Hall.

Cavallo, A. M. L. (1996). Meaningful learning, reasoning ability, and students' understanding and problem solving in genetics. *Journal of Research in Science Teaching, 33*, 625-656.

Cepni, S. (1997). Lise Fizik I Ders Kitaplarında Öğrencilerin Anlamakta Zorluk Cektikleri Anahtar Kavramların Tespiti. *C.U. Egitim Fakultesi Dergisi, 2*(15), 1-8.

Cepni, S. (2010). *Arastırma ve Proje Calısmalarına Giris*. Trabzon.

Cepni, S., Akdeniz, A., & Keser, O. F. (2000). *Fen Bilimleri Ogretiminde Butunlestirici Ogrenme Kuramına Uygun Ornek Rehber Materyallerin Gelistirilmesi.* Paper presented at the 19. Fizik Kongresi, Elazıg.

Chambers, S. K., & Andre, T. (1997). Gender, prior knowledge, interest, and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching, 34*, 107-123.

Dalkiran, G., & Kesercioglu, T. (2005). *Kavram Haritalari ile Kavramsal Degisim Metinlerinin Ogrencilerin Fen Bilgisi Dersine Olan Tutumlarına Etkisi ve Ogrenci Gorusleri*. Paper presented at the XIV. Ulusal Eğitim Bilimleri Kongresi, Denizli.

Er Nas, S., Cepni, S., & Coruhlu, T. (2010). 5E Modelinin Derinleşme Aşamasına Yönelik Geliştirilen Materyalin Etkililiğinin Değerlendirilmesi. *Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi, 29*(1), 17-36.

Er Nas, S., Cepni, S., Yildirim, N., & Senel, T. (2007). Çalışma Yaprağının Öğrenci Başarısı Üzerindeki Etkisi: Asit Baz Örneği. *Yeditepe Üniversitesi Eğitim Fakültesi Dergisi, 2*, 1-17.

Ergin, I., Kanlı, U., & Tan, M. (2006, 06-08/09/ 2006). *Fizik Egitiminde 5E Modelinin Ogrencilerin Akademik Basarisina Etkisinin Incelenmesi.* Paper presented at the VII. Fen Bilimleri ve Matematik Egitim Kongresi Bildiriler Kitabı, Ankara.

Eryilmaz, A. (2002). Effects Of Conceptual Assignments And Conceptual Change Discussionns On Studendts' Misconceptions And Achievement Regarding Force And Motion. *Journal of Research in Science Teaching, 39*(10), 1001-1015.

Gurses, E. (2006). *Durgun Elektik Konusunda Yapılandırmacı Ogrenme Kuramına Dayalı, 5E Modeline Uygun Olarak Gelistirilen Dokumanların Uygulanması ve Etkililiginin Incelenmesi.* (Yuksek Lisans Tezi), K.T.U., Trabzon.

Hand, B., & Treagust, D. F. (1991). Student achievement and science curriculum development using a constructive framework. *School Science & Mathematics, 91*(4), 172-176.

Isman, A., Baytekin, F., Balkan, M. B., & Horzum, M. (2002). Fen Bilgisi Eğitimi ve Yapısalcı Yaklaşım. *The Turkish Online Journal of Educational Technology (TOJET), 1*(1), 41-47.

Kanselaar, G. (2002). *Constructivism and Socio-constructivism.* Retrieved from http://edu.fss.uu.nl/mede-werkers/gk/files/Constructivism-gk.pdf

Karacam, S., & Digilli Baran, A. (2015). The effects of field dependent/field independent cognitive styles and motivational styles on students' conceptual understanding about direct current circuits *Asia-Pacific Forum on Science Learning and Teaching, 16*(2).

Kılavuz, Y. (2005). *The Effects of 5E Learning Cycle Model Based on Constructivist Theory on Tenth Grade Students Understanding of Acid –Base Concepts*. (Msc Thesis), Middle East Technical Unıversıty, Ankara.

Kor Ayas, S. (2006). *Ilkogretim 5.Sınıf Ogrencilerinde 'Yasamımızdaki Elektrik' Unitesinde Gorulen Kavram Yanilgilerinin Giderilmesinde Butunlestirici Ogrenme Kuramına Dayali Gelistirilen Materyallerin Etkisi*. (Yayımlanmamis Yuksek Lisans Tezi), KTU, Trabzon.

Kucukozer, H. (2004). *Yapılandırmacı Ogrenme Kuramına Dayalı Olarak Gelistirilen Ogretim Modelinin Lise I. Sınıf Ogrencilerinin Basit Elektrik DevrelerineİIliskin Kavramsal Anlamalarına Etkisi*. (Yayımlanmamış Doktora Tezi), Balıkesir Universitesi, Balıkesir.

Lawson, A. E. (2001). Using the learning cycle to teach biology concepts and reasoning patterns. *Journal of Biological Education, 35*, 165-168.

Lewis, D. (2001). Objectivism vs. Constructivism: The Origins of This Debate and the Implications for Instructional Designers. Retrieved from http://www.coedu.usf.edu/agents/dlewis/publications/Objectivism_vs_Constructivism.htm

Limon, M. (2001). On the Cagnitive Conflicts as an İnstructional Strategy for Conceptual Changes: A Critical Appraisal. *Learning and Instruction, 36*(4-5), 357-380.

Lord, T. R. (1999). A Comparison Between Traditional and a Constructivist Teaching in Enviromental Science. *The Journal of Environmental Education, 30*(3), 22-28.

Marshall, J. A., & Dorward, J. T. (2000). Inquiry experiences as a lecture supplement for preservice elementary teachers and general education students. *American Journal of Physics Supply, 68*, 27-36.

MMS. (2002). Web Site of Miami Museum of Science, Constructivism and Five E's. Retrieved from http:// www.Miamisci.org.ph/Ipintro5e.html

Newby, E. (2004). Using Inquiry to Connect Young Learners to Science, Natioal Charter Schools Institute. Retrieved from http://www.nationalcharterschools.org/uploads/pdf/resource_20040617125804_Using%20Inquiry.pdf

Orgill, M., & Thomas, M. (2007). Analogies and the 5E Model. *The Science Theacher, 7*(1), 40-45.

Osborne, R., & Wittrock, M. C. (1983). Learning Science a Generative Procers. *Science Education, 67*(4), 489-508.

Ozdemir, O. (2006). *Ilkogretim 8. Sınıf Turun Devamliligini Saglayan Canlilik Olayi (Ureme) Konusunun Calisma Yapraklari ile Ogretiminin Ogrenci Erisisine ve Kaliciligine Etkisi*. (Yuksek Lisans Tezi), Dokuz Eylül Üniversitesi, Izmir.

Ozmen, H. (2004). Fen Ogretiminde Ogrenme Teorileri ve Teknoloji Destekli Yapilandirmaci (Constructivist) Ogrenme. T*he Turkish Online Journal of Educational Technology (TOJET),, 3*(1), 100-111.

Ozmen, H., & Yildirim, N. (2005). Calisma Yapraklarinin Ogrenci Basarisine Etkisi: Asitler ve Bazlar Ornegi. *Turk Fen Egitimi Dergisi, 2*, 124-142.

Ozsevgeç, T. (2007). *Ilkogretim 5. Sinif Kuvvet ve Hareket Unitesine Yonelik 5E Modeline Gore Gelistirilen Rehber Materyallerin Etkililiklerinin Belirlenmesi*. (Doktora Tezi), KTU, Trabzon.

Powell, A., Farrar, E., & Cohen, D. (1985). *The shopping mall high school: Winners and losers in the educational marketplace.* Boston: Houghton Mifflin.

Saglam, M. (2006). *Isik ve Ses Unitesine Yonelik 5E Etkinliklerinin Gelistirilmesi ve Etkililiginin Degerlendirilmesi.* (Yayınlanmamış Doktora Tezi), KTU, Trabzon.

Saka, A. (2006). *Fen Bilgisi Ogretmen Adaylarinin Genetik Konusundaki Kavram Yanilgilerinin Giderilmesinde 5E Modelinin Etkisi*. (Doktora Tezi), KTU, Trabzon.

Salomon, G. (1999). Novel Constructivist Learning Environments and Novel Technologies: Some Issues to Be Concerned With. *Research Dialogue in Learning and Instruction, 1*(1), 3-12.

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Costu, B. (2016). Investigating the effectiveness of an active learning based-interactive conceptual instruction (ALBICI) on electric field concept. *Asia-Pacific Forum on Science Learning and Teaching, 17*(1).

Sensoy, O., Yildirim, H. I., & Aydogdu, M. (2006). *Fen Eğitiminde Yapısalcı Yaklaşımın Fen Bilgisi Öğretmen Adaylarının Başarı, Problem Çözme Becerileri ve Özyeterlik Düzeylerine Etkisi.* Paper presented at the VII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Ankara.

Seyhan, H. G., & Morgil, I. (2007). The effect of 5E learning model on teaching of acidbase topic in chemistry education. *Journal of Science Education, 8*(2), 120-123.

Sezen, G., Konur, K., & Cimer, A. (2008). *Sinif Ogretmeni Adaylari Acisindan 5E Ogretim Modeline Dayali Fen ve Teknoloji Uygulamalarini Degerlendirilmesi*. (Yuksek Lisans Tezi), Rize Universitesi, Rize.

Sifoglu, N. (2007). *Ilkogretim 8. Sinif Fen Bilgisi Dersinde Yapisalci Ogrenme ve Probleme Dayali Öğrenme Yaklaşımlarının Öğrenci Başarısı Üzerine Etkisi.* (Yuksek Lisans Tezi), Gazi Universitesi, Ankara.

Smerdon, B. A., Burkam, D. T., & Lee, V. E. (1999). Access to Constructivist and Didactic Teaching: Who Gets İt? Where is İt Practiced? *Teachers College Record, 101*(1), 5-34.

Teltik Baser, E. (2008). *5E Modeline Uygun Öğretim Etkinliklerinin 7. Sınıf Ogrencilerinin Matematik Dersindeki Akademik Başarılarına Etkisi.* (Yuksek Lisans Tezi), Gazi Universitesi, Ankara.

Turker, H. (2009). *Kuvvet Kavramına Yönelik 5E Öğrenme Döngüsü Modelinin Anlamlı Öğrenmeye Etkisinin İncelenmesi.* (Yuksek Lisans Tezi), Nigde Universitesi, Nigde.

Walker, C., & Angela, T. (1998). A Colctive Effort Classroom Assessment Technique: Promoting High Performance in Student Teams. *New Directions For Teaching and Learning, 75*, 101-112.

Wang, T., & Andre, T. (1991). Conceptual change text versus traditional text and application questions versus no question in learning about electricity. *Contemporary Educational Psychology, 16*, 103-116.

Wilder, M., & Shuttleworth, P. (2004). Cell inquiry: A 5E learning cycle lesson. *Science Activities, 41*(1), 25-31.

Yildiz, E. (2008). *5E Modelinin Kullanildigi Kavramsal Degisime Dayali Ogretimde Ust Bilisin Etkileri: 7. Sinif Kuvvet ve Hareket Unitesine Yonelik Bir Uygulama*. (Doktora Tezi), Dokuz Eylul Universitesi, Izmir.

Appendix

Some examples of applications