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The Effect of 7E Model on Conceptual Success of Students in The Unit of Electromagnetism

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Abstract
The aim of this study was to investigate the impact of the course materials developed in accordance with 7E model in the unit of electromagnetism in high school physics class on students' conceptual success. The present study was conducted with a total of 52 11th grade students in two separate classrooms at a high school. The action research design was used as the research method. The data of the study were collected through worksheets, open-ended and multiple-choice conceptual achievement tests and individual interviews. The worksheets, which were developed in order to ensure conceptual change and development based on experimental activities, were prepared and administrated in accordance with 7E model. In the research, 6 students with high level, moderate level and low level of conceptual changes were interviewed about their achievements. The activities and materials, which were applied according to the average scores of students, were found to be effective on conceptual development and eliminating existing misconceptions of students about the subject of electromagnetism. Recommendations were made in accordance with the findings obtained.
Keywords: Constructivist learning theory, 7E model, worksheet, electromagnetism.

INTRODUCTION

Scientific information develop and change as a result of new ideas from the history of humanity until today. Therefore, there is a principle of continuity and vitality in science. This dynamic nature of science changes the nature of society needs in the name of development of technology and facilitating life by using time and knowledge effectively. The eligibility of individual qualifications to this age to meet these needs are considered to be an important gap in terms of education. In particular, learning to learn, access to information, productivity and qualified nature are some of these qualifications. Closing this gap and being even ahead of the time will be possible by accelerating changes in education. When the structure of knowledge and learning process is examined in education as well as in science, it will be seen that the current teaching and learning models are not enough and therefore they have to be improved or other models are required.

Information is formed in the mind of a learner by internalizing new information with a particular awareness and renaming this new information with some adjustments. Information cannot be internalized or assimilated in a simple manner. Information is issuance of new sense by interpreting previously created cognitive structures with new achievements (Fosnot, 2013). Thus, information is the whole conceptual patterns changing gradually. The meaning of information and its usability and permanency depends on regular organization of the concepts related to the subject (Gunes et al., 2011).

Particularly, in our world developing with technological changes, the place of physics and its applications is quite important. However, physics is a boring course for many students. On the other hand, abstract subjects such as electricity, electric field, magnetism, electromagnetic induction and electromagnetic waves lead to misconceptions in cognitive processes and logical thinking development of students and consequently cause many problems experienced by students

(Yigit, Akdeniz and Kurt, 2001). If students understand that physics subjects are not abstract and they are directly related to their lives, they may learn physics by feeling since their interest and attention to the course will be improved. This association may facilitate their learning (Cepni, Ayas, Johnson and Turgut, 1997).

In addition to the results of studies conducted on learning, teaching and science education, the nature of physics and subjects of physics highlights the use of some methods while teaching subjects of physics. In order to have a meaningful and permanent learning in physics classes, the most efficient approaches including activities aiming conceptual development, based on the context in which they encounter in real life, with validity of the initial information is checked, require students to be mentally and physically active, emphasize the importance of quick feedbacks with team work in laboratories and classroom activities should be used (Gunes et al., 2011). In this context, it is very important to select the most appropriate teaching method or methods in order to allow them to configure the achievements of physics class in a meaningful way and use these achievements in the necessary environments. What to teach, how to teach and how to perform evaluation are the main questions that need to be asked together to teach a course. Therefore, the curriculum, course materials, books, methods and techniques must be able to ensure the realization of meaningful learning for students.

It is very well-known that students understand subjects easier if they experience-live them and associate these information more accurately with events they encounter in everyday life. Examples from real life and associating the subject with daily life will help students to be more willing to participate in the science and physics classes, in which they normally feel nervous. The inquiry and research-based teaching methods developed by taking the steps followed in the scientific research process into account (discovery, exploration and critical research method) and conceptual change based teaching methods (conceptual change texts, analogies, 5E and 7E models) seem to be more prominent teaching methods compared to other methods. The use of these methods a little more than others will allow students to have more regular conceptual frameworks and skills and have a better learning of the subjects of physics (Acıslı 2010; Gurbuz 2012; Hırca 2008; Kanlı 2007; Savas 2009 and Ozsevgec 2006).

Purpose of the Study

Electromagnetism unit contains quite abstract concepts in terms of content like magnetic field, magnetic poles, magnetic permeability, electrical current, magnetic flux and electromagnetism and induction. In this unit with many abstract subjects, where students experience some difficulties, it is aimed to develop and use teaching materials in accordance with 7E model and present its effect on the conceptual success of students. In this regard, the following question is sought to be answered:

- How teaching materials developed based on 7E model affect students' conceptual development related to electromagnetism unit and eliminate the existing misconceptions?

The Importance of Research

Many of the concepts involved in physics consists of abstract concepts. According to the earlier studies, students cannot easily learn the concepts of physics and they have misconceptions about the course (Cepni et al., 1997; Eryilmaz, 2002). A matter of physics manifests itself in almost every area of our lives such as an incident, event or our experiences with a mechanical device or technological device is not enough to explain physics. This deficiency is emerging as a problem in front of students and educators (Aycan and Yumusak, 2003). In several studies, it is emphasized that worksheets have a positive effect on the success of students in the education of concepts.

Since electricity and magnetism principles used in the compass to find the direction, electric production, lowering and raising the voltage, giant electromagnet cranes in a junkyard, achieving sound from the speaker, in external memory devices and many other areas cannot be seen with naked eyes, they are considered to be abstract. This conclusion is consistent with findings of Aycan and Yumusak (2003). Table 1 shows titles of the units with percentages, in which students' experience difficulties.

Table 1. *Percentage Distribution of Physics Subjects Students Experience Difficulties*

Subjects	**%**	**Subjects**	**%**
Electromagnetic induction	61.3	Electric circuits	26
Waves	46.9	Electric current	25.6
Impulse and momentum	44.3	Energy	25.1
The movement of charged particles in the electric field	43	Newton's laws of motion	24
Light theories	41.8	Electrostatics	18.4
Magnetism	41.4	Electrical conductivity	12.5
Motion on earth	37.6	Interaction force between charged particles	10.2
Motion	37.3	Force	7.5
Light	36.3	Electric and electric charge	6.6
Atom Theory	35.3	Substances and Heat (Heat-Temperature)	4
Solar Energy	33	Density	1.3
Electrical current sources	29	Substances and Their Properties	0.7
Measurement of the electrical charge and electric current	26.2	Mass and weight	0

Considering the data given in Table 1, 61.3% of the students experience difficulties to understand "electromagnetic induction" and 41.4% of the students experience difficulties to understand "magnetism", respectively. The easiest subject is found to be “mass and weight” with a difficulty rate of 0% (Aycan and Yumusak 2003). Similar to other courses, students have some misconceptions in the electricity and magnetism subjects of physics course. In this study, misconceptions of students in regard with various concepts such as electric current, electric fields, magnetic fields, magnetic flux and force lines were investigated and their misconceptions were determined in various styles (Barrow, 2000; Tanriverdi, 2001). These misconceptions can be summarized as follows:

Magnetic Field

1. The magnetic poles can be distinguished from each other (North and South).
2. Magnetic flux and field lines are the same thing.
3. The magnetic flux is the current of magnetic field.
4. Magnetic field lines start from one pole and end in the other.
5. Magnetic force can affect motionless charged particles.
6. Charged particles move to one pole of the magnet.
7. The magnetic field is not three-dimensional.
8. Magnetic field lines are holding us on earth.

Electromagnetic Induction

1. Work is not needed to generate electricity.
2. Voltage is induced only in the closed circuit.
3. Not change of magnetic flux, but magnetic flux induction is the cause of Electromotive Force (ε).
4. Current and voltage are always constant in alternating current circuits.

5. There is no loss of energy in the transformers.
6. In transformers, more energy can be obtained from output with less energy input.
7. Transformers can be used in direct current voltage.

In line with the findings mentioned above, the course administrated according to the constructivist approach based 7E model, which is has positive effects on the conceptual development of students in the electromagnetism unit, is expected to have the following results;

1. To what extent it will help students in meaningful learning and in building relationships between concepts,
2. To what extent the subject will be understood by students with worksheets prepared as an assistive material rather than guide books,
3. To what extent this model will help eliminating misconceptions,
4. Contribute to the future studies to be conducted in this area.

METHOD

In this study, the “action research” method, which is one of the qualitative research designs, was used by considering the research objective. In order to determine the conceptual development, multiple-choice academic achievement test, open-ended concept development questions and interview questions were developed and administrated. In addition, worksheets based on experimental activities including goals and objectives of the research were developed according to the 7E model.

"Data sources diversification" method was used to collect and evaluate the data in order to improve the reliability of the research. Open and closed-ended tests, worksheets and interviews were used to describe the conceptual development. In this way, the relationships between the data and findings will be established.

Study Group

The study group consists of 11th grade students from two different classrooms in a public high school in Turkey. A total of 52 students participated in the study since there were 26 students in each classroom. Easily accessible sampling was conducted. The high school, where one of the researches is working, was selected; because it is an equipped school terms of equipment and technical facilities.

Data Collection Tools

In the qualitative studies, using multiple data collection tools help researches to ensure the reliability of the findings obtained in the studies McMillian and Schumacher, 2010). Therefore, data was collected from different data sources. In line with the information in the literature, many data collection tools were developed and used to increase the reliability of the study. In this regard, he following data collection tools were used;

1. ECAT conceptual achievement test (all subjects),
2. EOCT conceptual achievement exam (all subjects),
3. Interview questions for conceptual development of students (six students),
4. Seven worksheets prepared according to the 7E model (all subjects),
5. Developing Worksheets

Students participated in the study learnt electric current, potential difference and resistance as well as Ohm's Law, serial and parallel connections, magnetic effect of electric current, electrical field, electrical power and electrical potential energy subjects in the previous years. In the curriculum of 11th grade, more advanced topics such as magnetic poles, the magnetic field, the magnetic properties of materials, magnetic permeability, magnetic force, magnetic flux, magnetic induction, Faraday and Lenz's Laws are included.

Within the scope of this study, worksheets were created for 11th grade electromagnetism unit by considering the 7E model reported by Keser (2003) in the lectures according to the constructivist approach. This model consists of excite, explore, explain, elaborate, extend, exchange and evaluate steps. (Cepni et al., 2001; Kanlı, 2007). The content of these steps is as follows:

1. In the "excite" step, teachers ask questions to awaken curiosity, determine the background and prior knowledge of students and simple shows, short videos or animations are watched.
2. In the "explore" step, students perform some experiments and observations in order to gain new information by using their prior knowledge and they seem questioning and active in this step.
3. In the "explain" step, students tell what they achieve based on the results of the previous explore step and teachers summarize these achievements with a scientific language.
4. In the "elaborate" step, new activities are performed in order to apply and consolidate new definitions, descriptions and skills.
5. In the "extend" step, students establish relationships between their new achievements and existing concepts and subjects in other areas and in their real lives and make explanations about these relationships.
6. In the "exchange" step, students share their experiences and new achievements with other students of the group and complete their achievements.
7. In the "evaluate" step, students find a chance to evaluate themselves about their conceptual development and skills and teachers use various assessment and evaluation instruments to monitor and evaluate students.

Opinions and views of physics teaches and academicians with PhD or experience in the area of preparing worksheets were benefited in the process of preparation of worksheets. Worksheets were prepared after reviewing the related literature and evaluating the results of the earlier studies conducted about magnetism concepts related to the science education based on constructivist learning theory.

Worksheets developed in this study were designed in accordance with the 7E model. These worksheets will allow students to reveal relevant existing cognitive structures in the mind, encourage them to seek for more advanced information, extend sensory data with prior knowledge and configure the new information. A total of seven worksheets were prepared in accordance with the number, nature and intensity of specific goals and objectives within the scope of the subject. In the worksheets, activities were included in order to reach the unit's achievements and avoid misconceptions stated in the literature.

The following points are taken into consideration in the creation of the worksheets in accordance with the model stated by Demircioglu and Atasoy (2006) in regard with goals and objectives to be achieved in the curriculum:

1. ***Exciting students:*** All learning activities were performed around the student and these activities were associated with high level new tasks and problems in order to achieve the goals of the activities, reveal students' prior knowledge and excite them about the subjects. For this purpose, exciting titles were preferred and debatable questions, shows or short videos were used. In addition, cartoons that may represent all steps of 7E model were used.
2. ***Activities about the subject:*** Students were given tools list and experimental setup instructions to make research; and blank areas were provided in order to record the data and

findings of the activities, create graphs and tables and establish causal link between questions. These activities were planned to be completed in the normal time of the class and targeted times were expressed.

3. ***Explanation and exchange of ideas:*** Since constructing information is closely associated with mutual interaction in social environments, sections were created to use scientific terms and generate formulas in order to test different viewpoints of students and conclude the topic in the light of findings of team works and activities.
4. ***Implementing new information on related situations:*** Sections were designed in order to make explanations about a daily life related topic, working principle of a technological device or an incident, or direct to new activities or personal or group performance depending on assignments.
5. ***Evaluation:*** Worksheets were designed to allow both students and teachers to make evaluations by looking at answers of students given in response to the questions and their statements about the results of the activities performed during the class.

The design of worksheets in accordance with research and teaching model and evaluation questions about activities were created by using physics textbooks of many high schools and universities and electronic sources in the internet. Worksheets were copied in color for each students in ensure their inclusion and be responsible. Furthermore, the course is administrated in technology-assisted physics laboratory where activities can be implemented easily. Activities were performed by the teacher before the class and measures were taken for possible problems and deficiencies were eliminated. The worksheets were reviewed by academicians and physics teachers prior to the study and preliminary assessment was performed according to the "worksheet evaluation form". Accordingly, adjustments were made in the activities in order to complete the units in the targeted time and use the time effectively. In the aftermath of this preparation, the pilot study was conducted with 47 students in order to determine the missing or unclear parts of the worksheets, see the applicability of study and gain experience by the researcher. As a result of the pilot study conducted at the physics laboratory of the same school, the points where students have difficulties to understand were identified and readability of the materials was provided. In addition, the language of the worksheets was simplified and necessary changes were made. During the study, the researcher-teacher walked between groups and guided students and led them discuss the activities and questions.

Electromagnetism Conceptual Achievement Test (ECAT)

Having a qualified measurement instrument requires to comply with the test development process consists of several stages. Test development is a dynamic process consists of many stages such as i) informing students about date, type and level of the tests, ii) establishment of a question bank, iii) selection of the items to be included in the test by utilizing the table of specifications, iv) configuring the test, administrating on students and scoring (Bayrakceken, 2008). In order to determine the effect of teaching materials, which were developed by the teaching model applied within the scope of the study, on conceptual development of students, "Electromagnetism Conceptual Achievement Test" (ECAT) was developed by the researcher by taking Bloom's new classification into account.

A test should be reliable and valid in order to serve its purpose. Validity of an instrument is the degree of how accurate an instrument measures a certain feature without interfering with other features (Doganay and Karip, 2006). In order to so how accurate an instrument measures a certain feature, either a sample previously known to what degree it is valid to measure this certain feature or another measurement tool that is known to be valid to measure the same feature should be available (Turgut, 1995). Item analysis is recommended to increase the validity of the test. Item analysis calculates discrimination index and item difficulty of each item. The discrimination index of an item varies between -1 and +1 and the test is accepted to be more valid as discrimination index of the item becomes higher. Items with a discrimination index higher than 0.4 are considered to be “very good”, items with a discrimination index between 0.3-0.4 are considered to be “good” and items with a discrimination index between 0.2-0.3 can be used in case of necessity or if they are corrected. Items with a discrimination index lower than 0.2 shouldn’t be used (Kalaycı et al, 2007).

Reliability is having the same results in all measurements from a measuring tool. In other words, a measurement tool should measure the desired feature in a stable manner (Turgut, 1995). Reliability shows consistency of all questions in a test or survey with each other and to what extent the scale used reflects the problem considered (Kalaycı et al, 2007).

The following activities were performed in the development process of the test:

1) The issues in the subject of "Electromagnetism", where students have difficulties to understand, or misconceptions of students were tried to be determined in accordance with the earlier studies in the literature and interviews conducted with physics teachers experienced in this area.
2) 36 multiple-choice questions were prepared in accordance with objectives and achievements of the course. In addition, misconceptions stated in the literature were used as a distractor in the questions. In the study, the hypothesis suggesting that if a students selected the distractor answer, it reflects the misconception of the student, is accepted (Coştu, Karataş and Köse, 2003a.). In the solution process

of each question, steps including cognitive, affective and psychomotor skills were prepared as the answer key and achievement items in the questions were converted into ECAT table of specifications. Then, opinions of three academicians and one physics teacher were received in order to determine the degree of compliance of the materials and ensure reliability of the items in the classification. For this purpose, “ECAT table of specifications expert assessment form" was designed by adapting from the form developed by Sekerci (2013) and evaluated in accordance with expert opinions. After evaluations of the experts, some of the questions, in which students may have difficulties to understand and misconceptions, were removed and the pilot achievement test including 30 multiple-choice questions was ready to be administrated.

3) The questions were reviewed by language experts and examined in terms of expression and grammar rules.
4) The pilot study was conducted by administrating the test with 30 multiple-choice questions on a total of 219 students completed the "Electromagnetism" unit in 3 different high schools.
5) The item analysis of the test was performed after conducting the pilot study. As a result of the pilot study, 59 students (27%) were selected from lower and higher groups depending on their success to perform the item analysis.
6) After the pilot study, some of the questions were removed from the test due to the low discrimination index value and some revisions were made on some others.

After the pilot study, the degree of difficulties experienced by students in the test and the time they spent to answer the questions was tried to be determined. Then, some of the expressions that are not understood by students were revised.

In regard with the reliability of the test, split-half method, which is one of the methods used in the scales where answers are scored as 1 and 0, was used. Since reliability coefficient of one half of the test cannot give an indication about the reliability of the entire scale, it is accepted as the lower limit of the reliability of the entire test. Reliability coefficient of the entire test can be found by Spearman-Brown formula. After performing item analysis for the test developed, some of the questions in the tests were excluded and the reliability coefficient of the remaining 25 questions was found to be r=0.768 according to the analysis results obtained from SPSS software. Considering these results, this test can be considered as a well-designed test in terms of discrimination index and item difficulty values (Bayrakceken, 2008).

After these processes, the ECAT test with 25 questions was ready. This test was simultaneously applied on both classes after completion of the activities.

Electromagnetism Open-Ended Conceptual Achievement Test (EOCT)

Open-ended tests were used since these tests allow students to be more descriptive and they can realize the relationships between concepts and express their thoughts freely in terms of their answers to determine the understanding level of students. Although we can get information about misconceptions of students in multiple-choice tests, we know nothing about the reasons of their answers. Therefore, tests requiring written responses are preferred because they provide the opportunity to learn more about students. They are widely used especially to assess level of understanding of the concept (Calık, 2006). In the study, "Electromagnetism Open-Ended Conceptual Achievement Test" (EOCT) was developed by the researcher by taking

Bloom's new classification into account in order to determine the effect of teaching materials, which were developed by the teaching model applied within the scope of the study, on conceptual development of students. There were 10 open-ended questions in the achievement test. In addition, assessment and evaluation activities proposed in the curriculum were examined and used in accordance with the objectives of the study. Since multiple gains would be examined in each question, the cognitive, affective and psychomotor skills needed by students to answer the questions were listed.

Then, EOCT table of specifications was prepared by using the achievement items in the list. Then, opinions of three academicians and one physics teacher with an experience of 22 years in the area were received in order to determine the degree of compliance of the items in the classification. "EOCT table of specifications expert assessment form" was used to ensure the reliability of table of specifications.

Semi-structured interviews for achievements (SSIFA)

The semi-structured interviews for achievements was designed to determine conceptual development and cognitive restructuring towards goals and achievements at the end of the study. It was conducted over 5 questions prepared within the scope of "Electromagnetism" unit. The reliability and predictive validity of the questions were ensured by performing revised Bloom classification of achievements of the questions with two academicians and three physics teachers. Academicians were experts in the field since they conduct studies about program evaluation and development. Then, interviews were conducted by using the semi-structured interview form developed to determine the targeted achievements.

Pilot interviews were conducted with two students individually by using the SSIFA form to determine the interview times and understandability of the questions were discussed.

Then, the final version of the form was developed by making necessary revisions and corrections.

Analysis of Data Obtained from the Study

Analysis of the Findings Obtained From ECAT

Within the scope of the study, ECAT test including 25 multiple-choice questions was administrated to evaluate the targeted achievements. As a result of these tests, each correct answer was given four points and the total scores were calculated. Given the correct answers, the cognitive processes and achievements required for the solution given in the table of specifications are considered to be used. The evaluation of scores are organized in accordance with assessment and principles of the Ministry of Education as follows;

Score Range	**Grade**
85.00-100	Very Good
70.00-84.99	Good
60.00-69.99	Moderate
50.00-59.99	Passed
0-49.99	Failed

Analysis of the Findings Obtained From EOCT

According to Calık (2006), categories can be used to evaluate the level of understanding of students according to their responses to open-ended questions. These categories were determined as no understanding (NU) with 0 points, misunderstanding (MU) with 1 point, insufficient partial understanding (IPU) with 2 points, partial understanding (PU) with 3 points and full understanding (FU) with 4 points by Abraham, Gryzybowski, Renner and Marek

(1992). Categories and their contents used to analyze the open-ended questions in this study are presented in Table 2.

Table 2. *Categories and their contents used to analyze and rate the open-ended questions in EOCT*

Understanding Levels	Scoring Criteria	Score
Full understanding (FU)	Valid answers including all achievements to reach the correct results.	4
Partial understanding (PU)	Valid answers that can be used to reach the correct results but including achievements partially.	3
Insufficient partial understanding (IPU)	Valid answers with partial achievements and incorrect relationships that are not sufficient to reach the correct results.	2
Misunderstanding (MU)	Scientifically incorrect answers with valid associations but less reasoning.	1
No Understanding (NU)	- Irrelevant or unclear answers - Blank - Repeating the question	0

FINDINGS

The findings obtained about "the effect of teaching materials that are developed in accordance with 7E model on conceptual success of students in the unit of electromagnetism" were depicted under three categories as findings obtained from EOCT, findings obtained from ECAT and findings obtained from SSIFA.

Findings Obtained from EOCT

The frequency and percentage distributions of scores of students received within the scope of scientific answers in EOCT are presented in Table 3.

Table 3. *Understanding Levels of Students According to Their Answers in EOCT*

	Frequency and Percentage Values by the Content of Answers									
	FU		**PU**		**IPU**		**MU**		**NU**	
Answer No	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
A-1	28	53.84	11	21.15	5	9.61	1	1.92	7	13.46
A-2	8	15.38	21	40.38	6	11.53	6	11.53	11	21.15
A-3	40	76.92	8	15.38	3	5.77	1	1.92	0	0
A-4	4	7.69	27	51.92	9	17.30	12	23.07	0	0
A-5	17	32.69	4	7.69	18	34.61	5	9.61	8	1.53
A-6	45	86.53	0	0	1	1.92	5	9.61	1	1.92
A-7	37	71.15	4	7.69	4	7.69	2	3.84	5	9.61
A-8	26	50.00	12	23.07	3	5.78	10	19.23	1	1.92
A-9	18	34.61	6	11.53	11	21.15	5	9.61	12	23.07
A-10	34	65.38	4	7.69	5	9.61	4	7.69	5	9.61

The total scores of students based on their understanding levels within the scope of achievements in EOCT are presented in Table 4.

Table 4. *Average Scores received from EOCT*

Students	**Scores received from questions**										**Total Score**	**100 Points***
	S-1	**S-2**	**S-3**	**S-4**	**S-5**	**S-6**	**S-7**	**S-8**	**S-9**	**S-10**		
Ave.	3	2.17	3.67	2.44	2.33	3.60	3.29	3.00	2.25	3.12	28.87	72.16

*: This calculation was made over (Total Score*100/40).

Considering the findings obtained from EOCT, as it can be seen in Table 4, only one student received a success score below 45 points among 52 students within the framework of passing the classroom principles determined by the Ministry of Education. Accordingly, the success rate was 98.07% in EOCT. The success rate of the group (72.16/100) is considered to be at “good level”. Therefore, it can be suggested that the activities performed and materials used are effective on the conceptual development of students. A similar situation is observed in the studies of Coştu, Karataş and Ayas (2003)b, Calık (2004, 2006), Saka (2006) and Ozsevgec (2007). In addition, the descriptive statistics values obtained through these points are given in Table 5.

Table 5. *EOCT Scores Descriptive Statistics Results*

Statistical Values	N	Range	X	Sd.
EOCT Score	52	57.50	72.16	14.65

Findings Obtained from ECAT

In this section, the findings of ECAT are presented. In addition, the descriptive statistics values obtained through scores of students are given in Table 6.

Table 6. *ECAT Scores Descriptive Statistics Results*

Statistical Values	N	Range	$\bar{X}$X	Sd.
ECAT Score	52	60.00	65.31	14.43

Considering the findings obtained from ECAT, 3 students received a success score below 45 points among 52 students within the framework of passing the classroom principles determined by the Ministry of Education. Accordingly, the success rate was 94.23% in ECAT. The success rate of the group (65.31/100) is considered to be at “moderate level”.

Findings Obtained from SSIFA

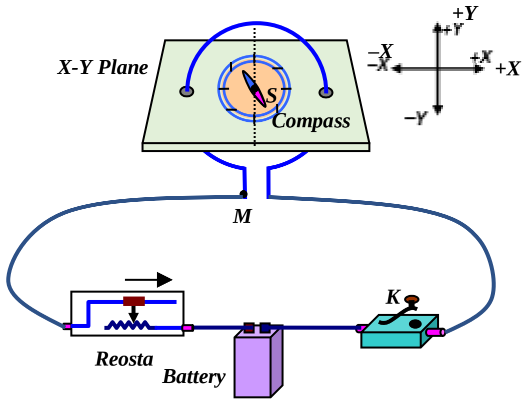
After ECAT, one student was randomly selected from each group including upper, lower and moderate groups from both classrooms and interviews were conducted with these six students and these interviews were recorded in audio and video. Each interview lasted 40 minutes in average.

The interview questions were given to the students since they contain visual elements and details of the subject in a format with spaces to write down the answers and they answered questions both in the written form and verbally. Their answers in response to the main questions are given in Tables. However, only an example of these tables (Table 7) for the first question is presented in this article to avoid occupying to much space with 31 pages. Then, the interviews conducted with students were turned into text documents and they were analysed.

Answers of students in response to question 1.1 and follow-up questions during the interviews are presented in Table 7. Students **S_{10}** and **S_{14}** answered "geographic north-south" in response to the question "What direction S Pole of the compass show?". However, when we asked some follow-up questions such as "What kind of material is needle of the compass is made of? How does it move?", they have corrected their answers as "magnetic north or south of Earth". As it can be seen in Table 7, students made an explanation that can be scientifically accepted as "*The compass is affected by magnetic field of the Earth and directed to magnetic north and magnetic south directions of Earth. Since the needle of the compass is a magnet, N side of the compass shows magnetic south of Earth and S side of the compass shows magnetic north of Earth.*" Some parts of the interview conducted with **S_{10}** are given below: (**R:** researcher, **S:** Interviewed Student)

Table 7. *Interview Questions about Magnetic Field of Earth and Responses of Students*

QUESTION-1) *The S pole of the compass shows the specified direction when the switch is open in the circuit that consists of a battery, rheostat and compass on the X-Y plane. If the switch is closed and slider of rheostat is moved in the direction of arrow, which direction the compass show? Please explain.*



Questions	Students	Answers
1.1) When switch is open, what can you tell by looking at the position of the compass? / Why is it in this direction? / What does S pole of the compass needle show in the world?	**S_4**	Earth's magnetic north and south poles.
	S_{10}	The direction or vector compass is showing is magnetic field of the Earth.
	S_{14}	Magnetic north of Earth.
	S_{41}	S pole of the compass show magnetic north of the Earth.
	S_{43}	Magnetic south-magnetic north
	S_{50}	It should directed to Earth's magnetic north.
Scientific Answer of the Question	*The compass is affected by magnetic field of the Earth and directed to magnetic north and magnetic south directions of Earth. Since the needle of the compass is a magnet, N side of the compass shows magnetic south of Earth and S side of the compass shows magnetic north of Earth.*	

Table 8. *Interview Questions about Magnetic Field of a Current-Carrying Circular Wire and Answers of Students*

1.2) What happens when the switch is closed?	S_4	The current flowing through a circular wire generates a magnetic field. These magnetic field vectors will be in this direction and this will affect as force. Naturally, the compass will turn in to this direction.
	S_{10}	If the switch is closed, current will flow through the circuit. A magnetic field will be generated around the circular wire.
	S_{14}	A magnetic field will be generated around the current. Therefore, the compass will deviate.
	S_{41}	Current flows through the circuit. This current will affect our compass.
	S_{43}	When the switch is closed, the circular wire will generate a magnetic field and it will affect our compass.
	S_{50}	When current flows through the circuit, the circular wire will generate a magnetic field. This affects the compass.
Scientific Answer of the Question		*Electric current will flow through the circuit due to the potential difference between opposite terminals of the battery when switch is closed. The circular wire with current generates a magnetic field. This will lead to a deviation in the compass located in the center of the circle.*

Student starts answering the question after reading;

S_{10}: First, no magnetic field will be generated around the circle since no current is flowing through the circuit when the switch is open. Therefore, the compass shows the direction of magnetic field of Earth. Therefore, we can draw magnetic field of Earth as magnetic field vector of Earth. Let's say it is B_{Earth}.

R: Well, which direction S pole of a compass show?

S_{10}: S pole is directed toward geographic north of Earth.

R: Yes.

S_{10}: Eeee

R: How about magnetic fields?

S_{10}: Towards magnetic south.

R: Ok, what letter do we use to symbolize south?
S_{10}: We use the letter "S" since it is the initial letter of South.
R: Well, does S value of the compass direct towards S pole of Earth?
S_{10}: No…
R: Then?
S_{10}: Compass… North Pole of Earth.

Answers of students in response to question 1.2 (*What happens when the switch is closed?)* and follow-up questions during the interviews are presented in Table 8. As it can be seen in Table 8, students gave scientifically acceptable answers such as "magnetic field is generated, the compass deviates" in response to a question about "*Effect of magnetic field on the compass*". Some parts of the interview conducted with **S_{43}** are given below;

R: Well, what happens if we close the switch? There is a power source in the circuit. What happens if we close the switch?
S_{43}: If we close the switch, a magnetic field will be generated around the circular wire and this field affects the compass.

Findings Obtained from Worksheets

Some active learning-oriented worksheets were developed in accordance with 7E model for students to have a better understanding of electromagnetism and scores of students received from these worksheets are presented in Table 9. The researcher has developed a score key to evaluate the scores of the students.

Table 9. *Scores received from Worksheets (WS)*

Student	Scores received from Worksheets							Average	Score/100*
	1.WS	2. WS	3. WS	4. WS	5. WS	6. WS	7. WS		
Average Score	47.85	47.23	46.79	45.98	45.69	46.77	46.92	46.75	82.01
Average Score in the 100 Points Grading System	83.94	82.86	82.09	80.67	80.16	82.05	82.32	82.01	**82.01**

*: This calculation was made over (Average *100/57).

As shown in Table 9, the average score received from the 1st worksheet was 47.85 out of 57 points which was 83.94 in the 100 points scoring system; the average score received from the 2nd worksheet was 47.23 which is corresponding to 82.86 in the 100 points scoring system; the average score received from the 3rd worksheet was 46.79 which is corresponding to 82.09 in the 100 points scoring system; the average score received from the 4th worksheet was 45.98 which is corresponding to 80.67 in the 100 points scoring system; the average score received from the 5th worksheet was 45.69 which is corresponding to 80.16 in the 100 points scoring system; the average score received from the 6th worksheet was 46.77 which is corresponding to 82.05 in the 100 points scoring system and the average score received from the 7th worksheet was 46.92 which is corresponding to 82.32 in the 100 points scoring system, respectively.

The descriptive statistical analysis results obtained from these scores are given in Table 10.

Table 10. *Descriptive Statistics Results of Scores Received from Worksheets*

Statistical Values	N	Range	$\bar{X}$	Sd.
WS Score	52	28.07	82.01	6.72

The following cases were identified regarding conceptual misconceptions seen in the answers or activities performed as part of the worksheets.

In rectangular prism magnets, some of the students stated that "broad-based surfaces could have only magnetic poles" about magnetic pole distribution of magnets before the 2nd activity of 2nd phase of the 1st worksheet. Accordingly, the frequency table about correction of this misconception after the study is given below.

Table 11. *Misconceptions about Magnet Pole Distribution*

	Misconception	**After the Activity**
Total of Student	20	0

Although a total of 20 students stated that "broad-based surfaces could have only magnetic poles" about magnetic pole distribution of magnets before the activity given in the worksheet, all students changed their minds after the activity.

Regarding this situation, **S29** stated that "magnet and nail attracts each other since they have opposite poles" in regard with an example given in the 1st worksheet; a bar magnet attracts a nail hanging on the wall when they get closer. This doesn't explain if both poles of the magnet is getting closer to the nail. Because ferromagnetic materials get new magnetic order at a time by the influence of external magnetic fields. Student didn't change his/her opinion after the activity.

In the 1st worksheet**, S37** stated that one of the poles of a bar magnet getting closer to an iron nail hanging on the wall would attract the nail while the opposite pole of the magnet repels the nail. However, the student changed his mind after the activity and stated that both poles of the magnet attract the nail. In the 2nd phase activity of 1st worksheet, **S41** stated that objects such as nail, buckle and needle have only one pole and magnets have two different poles. However, the student changed his mind in the activities about classifications of objects by their magnetic specifications in the 3rd worksheet. In the 2nd phase activity of 1st worksheet, **S44** stated that objects such as nail, buckle and needle have only one pole and magnets have two different poles and opposite poles repels each other. However, the student changed his mind in the activities about classifications of objects by their magnetic specifications in the 3rd worksheet.

Students were asked to answer the questions given in the 2.3 activity of 1st worksheet prior to the application in order to explore that electric field and magnetic field are different from each other. In this regard, Table 12 shows that whether their misconceptions about “the effect of a bar magnet on a glass rod or ebonite rod hanging on the wall from their centre of mass or on the leaves of a neutral electroscope” determined from their answers and frequency values about their incorrect answers given in response to the 2nd question in the evaluation section.

Table 12. *Misconceptions about Electric Field and Magnetic Field*

	Before the Activity	**After the Activity**	**Incorrect Answers Given in Response to the 2nd Question**
Total	33	1	6

In the worksheet, which was developed in order to see the misconceptions of students regarding that electric field and magnetic field are different from each other and magnets don’t have the same effect on electroscope and charged objects as electric field has”, misconceptions were observed in a total of 33 students prior to the activities. However, at the end of the activities, all students except one student (S26) corrected their misconceptions; however, in the evaluation section, 6 students gave incorrect answers to the 2nd question.

In the 2nd worksheet, **S_7**, **S_{15}** and **S_{16}** in the same group stated that "since middle part of the magnets is non-polar/ middle of the magnet has no poles, iron powders are lined up this way" for iron powders that are lined up properly in parallel directions due to the effect of magnetic fields of magnets with opposite magnetic poles facing each other. However, this alternative view was tried to be disproved in the 3rd question by showing the repelling force occurring when a magnet is fractured and pushed for unification (both broken pieces have N and S poles again). This misconception shows that students in the same group negatively affect each other.

Table 13 shows the frequency of misconceptions of students according to their answers given in response to 2nd and 6th questions in the evaluation section of 7th phase of the activities performed in the 3rd worksheet towards "The effect of magnetic field on objects is independent from their conductivity" (Table 13).

Table 13. *Electrical Conductivity and Magnetic Property*

	Misconception in the 2nd question	**Misconception in the 4th question**
Total	12	16

After exploring the differences between magnetic properties of objects, misconceptions were seen in 12 students in the 2nd question and in 16 students in the 6th question in the evaluation section, which is the 7th phase of 3rd worksheet that was developed towards logical reasoning of "the effect of magnetic field on objects is independent from their conductivity".

Table 14 shows the distribution frequency regarding whether students have misconceptions or corrected their misconceptions according to their answers given in response to the questions in the formulation and evaluation phases about “forces applied on stationary or moving charged particles by the magnetic field and electric field” in the 6th worksheet.

Table 14. *Effect of Electric Field and Magnetic Field on Free Charges*

	Misconception before the activity	**2. Activity Formulation**	**Explanation**	**Evaluation**
Total	31	0	0	4

In the activities performed in regard with “*Magnetic field applies force on moving charges and electric field applies force on stationary charges*”, misconceptions were seen in 31 students. However, in the stages of exploration and explanation, this misconception was corrected, but it was repeated in 4 students in the evaluation.

These results obtained with different tools for overall academic success are presented in Table 15 in order to get a general idea.

Table 15. *Students' Scores for Academic Success*

	ECAT Score	**EOCT Score**	**Average Scores Obtained From Worksheets**	**Average Score**
Total	65.31	72.16	82.01	**73.16**

According to the evaluations performed in order to determine the conceptual development, the average success of the sample was found to be 73.16, which is considered as a “good level”. There are similarities between results of this study and the results obtained in other studies in the literature (Calik, 2006; Coştu et al., 2003; Saka, 2006).

RESULTS AND DISCUSSION

The following results were obtained according to the findings of multiple data collection tools (EOCT, ECAT, worksheets and conceptual development interviews) used to determine the effect of educational materials developed in accordance with 7E teaching model on the conceptual development of students in the electromagnetism unit:

As seen in Table 15, according to the summary of the results obtained by multiple methods in the evaluation of students' conceptual development based on their academic achievements, students received 65.31 in average from ECAT, 72.16 from EOCT, 82.01 from worksheets and 73.16 from the entire results, respectively. According to these scores, the achievement level of students was found to be at a “good level”. According to these results, we can imply that both the method preferred in the teaching process and materials developed contribute in achieving academic goals. Results of the studies conducted by Acıslı (2010), Ergul (2008), Ernas (2008), Ersahan (2007), Gurbuz (2012), Hırca (2008), Kanlı (2007), Kılavuz (2005), Kurt (2002), Ozsevgec (2007), Saka (2006), Sengül (2006), Turgut and Gurbuz, (2011) in the literature in regard with contribution of constructivist approach to the academic achievement of students support this conclusion.

In the different stages of worksheets, effective results were obtained in the elimination of misconceptions of students at the end of the activities. However, in the conceptual examinations performed in the advanced stages by using logical reasoning questions, some of these misconceptions were observed in a few students. This is thought to be caused by negative interaction between students as well as effects of rote approach and resistance to conceptual development. The collected data, tables, graphs and explanations were not sufficient in the effective interpretation of the results and expressing cause and effect relationships. In the light of the interviews, the insufficient laboratory experience of students is considered to play a major role in this insufficiency.

In the literature, there are many qualitative and quantitative findings indicating that activities prepared in accordance with the constructivist approach develop scientific process skills of students in the classroom environment. On the other hand, according to the interview data and written opinions of students in several studies; social development and communication skills, hand skills, higher-order thinking skills and self-confidence of students are reported to be increased by activities prepared in accordance with the constructivist approach (Akerson et al. 2009; Bayrakceken et al., 2009; Boddy et al.2003; Bozdogan and Altuncekic, 2007).

Considering the research process with all aspects; using 7E teaching model in accordance with different grade levels covers a fairly laborious process in terms of the preparation process for the course, evaluation of measurement tools of the course and teaching the course. In the preparation period, preparation and supply of assistive course materials (worksheets, tests, assessment tools) and education environment (laboratory, course tools, test equipment, computers and projectors) would be troubled and troublesome. In a school, the use of same laboratory by different teachers teaching the same course and preparing the laboratory for different classes can also be a problematic process. In this regard, the following suggestions can be made for researchers who will conduct similar studies:

Suggestion for Teaching with 7E Model

Worksheets, alternative assessment and evaluation methods developed in accordance with 7E model seem to be quite effective for increasing students' conceptual success. Therefore, developing similar activities that are used in this study for many subjects of physics is deemed beneficial for physics education.

In this learning process, teachers should be encouraging, facilitating and questioning. At the same time, they have to design discussions on ideas and strategies that will create effective learning environments for students.

Due to the reminders of the previous week's activities, 1 hour for each class seems to be a disadvantage. 2-hour block classes are more efficient. Therefore, this factor should be taken into account when planning.

Students should be informed about the model prior to the activities if this is the first time and simple subjects should be covered at the beginning.

While creating groups for experiments in the activities, the number of students should be as low as possible in order to increase the interest and participation level of students and heterogeneous groups should be created.

Students should be encouraged for active participation in the activities and spokesman of the group should be changed regularly in order to mobilize students seem nervous to participate in the activities and discussions conducted to exchange ideas.

Suggestions for the Preparation and Administration of Worksheets

In order to develop an accurate conceptual understanding in students, activities should be developed by taking the misconceptions on the subject into account and suitable conditions must be provided for students to present their current opinions correct misunderstandings.

Sometimes, student express the relationships between the topic and related concepts with inverted or unscientific sentences. Therefore, the correct expression of the achievements may be allowing students to write down their opinions or select from judicial sentences offered by the teacher. In this way, students' misconceptions may be identified based on their responses and alternative views can be minimized.

Using visuals in the activities and including interesting questions, demonstrations, example events and problems at the beginning has a significant impact in increasing the interest of students to the course.

In the applications of 7E model, the subjects included in the activities must be associated with everyday life as much as possible in order to attract students' attentions, improve permanence of information and show that physics is intertwined with life. In this regard, examples related to transformation of objectives into technology should be given.

REFERENCES

Abraham, M.R., Gryzybowski, E.B., Renner, J.W., & Marek, A.E. (1992). Understanding and misunderstanding of eighth graders of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching, 29,* 105-120.

Acıslı, S. (2010). *The examination of the influence of the materials generated in compliance with 5e learning model on physics laboratory application* (Unpublished doctoral thesis), Ataturk University, Turkey.

Akerson, V. L., Townsend, S., Donnelly, L. A., Hanson D. L., Tıra, P., & Whıte, O. (2009). Scientific Modelling for Inquiring Teachers Network (SMIT'N): The Influence on Elementary Teachers' Views of Nature of Science, Inquiry, and Modelling, *Journal of Science Teacher Education*, 20, 21-40 DOI 10.1007/s10972-008-9116-5.

Aycan, S. & Yumusak, A. (2003). A study on the high school level of understanding of the topics in physics curriculum. *Journal of National Education*, 159, 171-180.

Barrow, L. (2000). Do elementary science methods text books facilitate the understanding of the magnet concepts?. *Journal of Science Education and Technology*, *9*, 199-205.

Bayrakceken, S. (2008). *Test development*. Emin Karip (Ed). *Measurement and evaluation*, (s.244-277). Ankara: Pegem Publishing

Bayrakceken, S., Canpolat, N., Karaman, S., Celik, S., Aggul, F., & Avinc, I. (2009). *Secondary and tertiary levels in the preparation of appropriate active learning activities constructivist approach to teaching chemistry, implementation and evaluation.* TUBITAK Project No: 107K095

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

Bozdogan, E. & Altuncekic A. (2007). Science teacher candidates' views on the availability of 5E teaching model. *Kastamonu Education Journal, 15*(2), 579-590.

Budak, I. (2000). *Developing and evaluating a computer-assisted mathematics teaching material for numbers* (Unpublished master thesis), Karadeniz Technical University, Turkey.

Coştu, B., Karatas, F. O. & Kose, S. (2003)a. Two-tier tests used to determine the level of understanding and misconceptions of students. *Pamukkale University Journal of Education, 13*(1) 54-69.

Coştu, B., Karatas, F. O. & Ayas, A. (2003)b. Using the worksheets in the teaching of concepts. *Pamukkale University Journal of Education, 14* (2), 33-48.

Calık, M. (2004). Examining the feasibility of dissolution and developed on the relationship between physical change worksheets, *Cukurova Unıversıty Faculty of Educatıon Journal 27*(2), 63-72.

Calık, M. (2006). *Devising and implementing guide materials related to solution chemistry topic in Grade 9 based on constructivist learning theory,* (Unpublished doctoral thesis), Karadeniz Technical University, Turkey.

Cepni S., Ayas A., Johnson D. & Turgut M. F. (1997). Teaching Physics. World Bank National Education Development Project Pre-Service Teacher Training. Ankara.

Cepni, S., San, H. M., Gökdere, M. & Küçük, M. (2001). *Examples of activities to the appropriate development model in structuring theory 7E minds in science teaching*. New Millennium at the beginning of the Year of Science and Education Symposium Proceedings, Maltepe University, İstanbul, (s. 83-190).

Demircioglu, H. & Atasoy, S. (2006). A model proposal for the development of worksheets. *Buca Faculty of Education Journal, 19*, 71-79.

Doganay, A. & Karip, E. (2006). *Planning and evaluation in education.* Ankara: Pegem Publishing.

Ergul, N. (2008). *Examine the achievement elementary 6th grade 'power and movement' and 'particle structure of substance' units which were studied according to constructivism theory and sentiments of about program* (Unpublished master thesis), Sakarya University, Turkey.

Ernas, S. (2008*). Determining effectiveness of the materials about "the ways of spread of heat" based on the elaborate stage of the 5E model* (Unpublished master thesis), Karadeniz Technical University, Turkey.

Ersahan, O. (2007). *Defining the effective instruction methods (role play and 5e instruction method) for teaching science-technology-society-environment skills in the learning area of substance and it's evolution for 6 th grade students* (Unpublished master thesis). Gazi University, Turkey.

Eryilmaz, A. (2002). Effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion, *Journal of Research in Science Teaching*, *39 (10)* 1001–1015.

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice*. New York: Teachers College Press.

Gunes, B., Akyuz, O., Saçlı, O.A., Mutus, H., Ates, S., Eryilmaz & Ulutas, S. (2011). Ministry of Education Board of Curriculum of Physics, Ankara.

Gurbuz, F. (2012). *The effect 7e model on academic achievement and retention of knowledge in the unit of "Electricity in our Life" in 6th grade science and technology* (Unpublished doctoral thesis), Ataturk University, Turkey.

Hırca, N. (2008). *An investigation of effects on conceptual change of developed materials based on 5E model in unit "work, power and energy"* (Unpublished doctoral thesis), Ataturk University, Turkey.

Kalaycı, S., Kayıs, A., Antalyali, O., Ucar, N., Demirgil, H., İsler, D & Cicek, E. (2007). *Multivariate statistical techniques*, Ankara: Asil Publishing.

Kanli, U. (2007). *The effects of a laboratory based on the 7e model with verification laboratory approach on students? development of science process skills and conceptual achievement* (Unpublished doctoral thesis), Gazi University, Turkey.

Keser, O. F. (2003). *Designing and implementing a constructivist learning environment for physics education* (Unpublished doctoral thesis), Karadeniz Technical University, Turkey.

Kilavuz, Y. (2005). *The effects of 5E learning cycle model based on constructivist theory on tenth grade students' understanding of acid-base concepts* (Unpublished master thesis), Middle East Technical University, Turkey.

Kurt, S. (2002). *Worksheets development according to constructivist view of learning in physics teaching* (Unpublished master thesis), Karadeniz Technical University, Turkey.

McMillan, J.H., & Schumacher, S. (2010). *Research in education: Evidence-based inquiry* (Seventh Edition). Boston: Pearson Education.

Ozsevgec, T. (2006). Determining Effectiveness of Student Guiding Material Based On the 5E Model in "Force and Motion" Unit. *Journal of Turkish Science Education, 3*(2), 36-48.

Ozsevgec, T. (2007). *Determining effectiveness of guided materials about force and motion unit based on the 5E model for elementary students* (Unpublished doctoral thesis), Karadeniz Technical University, Turkey.

Saka, A. (2006). *The effect of 5E model on removing svience student teachers' misconceptions about genetics* (Unpublished doctoral thesis), Karadeniz Technical University, Turkey.

Savas, B. (2009). Constructivist learning. A. Kaya (Ed). *Educational Psychology* (s.411-434). Ankara: Pegem Akademi.

Sekerci, A.R. (2013). *The effect of argumentation based instruction on students' argumentation skills and conceptual understanding in Chemistry laboratory* (Unpublished doctoral thesis), Ataturk University, Turkey.

Sengül, N. (2006). *Effect of active teaching methods based on constructivist theory on students' science achievement and attitude about flowing electricity unit* (Unpublished master thesis), Celal Bayar University, Turkey.

Tanrıverdi, İ. (2001). M*isconceptions on electricity and magnetism* (Unpublished master thesis), Suleyman Demirel University, Turkey.

Turgut, M.F. (1995). *Methods of measurement and evaluation in education* (10th ed.). Ankara: Yargici Press.

Turgut, U., & Gurbuz, F. (2011). Effects of teaching with 5E model on students' behaviors and their conceptual changes about the subject of heat and temperature. *International Online Journal of Educational Sciences, 3*(2), 679-706.

Yigit, N., Akdeniz, A.R. & Kurt, S. (2001). "*Development of worksheets in physics teaching",* New Millennium at the beginning of the Year of Science and Education Symposium Proceedings, Maltepe University, İstanbul, (151-157).