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Development Of Teacher Guidance Materials Based On 7E Learning Method In Virtual Laboratory Environment

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Abstract

As the positive effects of preparation of secondary education Physics and Chemistry curricula based on constructivist approach on the teaching process comes into prominence in Turkey, a variety of models such as 5E and 7E, which are the applications of this approach, has started to be used. However, in order to eliminate the limitations in conventional laboratory applications of these courses, the experiments should be supported with technological means and carried out on computer software and the internet environment. In this context, it is seen that the applications in this area are becoming widespread, taking into consideration the level of effect of the virtual laboratory programs, which are top-end computer software. However, for the activities aimed at providing guidance to teachers and the on-the-job training on effective and correct use of the virtual laboratory software programs are insufficient, teachers are unable to utilize them sufficiently. This situation makes it required to develop guidance materials to enable teachers, the most important factor of the program, to achieve the competency required for the field. The purpose of the study conducted in this context is to introduce the design stages of the activity based on the 7E Learning Model and developed in the virtual laboratory environment for the "Electric Current" subject included in the "Electricity and Magnetism" unit of the secondary education Physics course, and to evaluate them taking into consideration the opinions of the specialists and teachers in the field of physics education. Case study methodology was used in the study, which participated in by 4 physics education specialists, 6 physics teachers and 1 electrics teacher. Within the scope of the study, opinions of the specialists in physics education and of the teachers in the secondary education regarding the application were obtained using the 'Course Material Evaluation Scale" and semi-structured interviews. It has been concluded that the materials developed within the framework of the study taking into consideration the opinions of the specialists in physics education and of the teachers in the secondary education are effective.

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Keywords: Virtual labs; 7E learning model; physics teaching; electric current

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1. Introduction

The process of development of the physics curriculum in Turkey is underway, with special attention toward minimizing the problems encountered in application, taking into consideration the curriculum development activities conducted in developed and developing countries (Kurt and Yıldırım, 2010). However, in spite of development of new curricula for the physics education, inadequacies in utilization of different teaching methods other than the classical methods in the teaching process cannot be remedied (Afra, Osta and Zoubeir, 2007; Jaakkola and Nurmi, 2008; Karakuyu and Tüysüz, 2011; Tveita, 2000). On the other hand, it is stated that, regardless of how effective physics curriculum has been developed, the fact that teachers that are the executors of such curriculum are not aware of their roles and responsibilities in the execution process of the curriculum developed, and they that fail to fulfill these roles and responsibilities leads to failure of elimination of the problems encountered in the current situation (Planinic, 2005). In this case, it is emphasized that competencies such as investigative, independent thinking, interest in scientific studies, evaluation, etc. are specified among the basic skills required to be developed by students in the physics education. In this context, because of the positive effects of the applications based on constructivist approach in physics teaching in other countries, a variety of models such as 4E, 5E and 7E have started to be used in the learning cycle in Turkey (Kanlı, 2009; Ültay and Çalık, 2011). It is emphasized in studies conducted that the 7E model is considerably effective, enabling students to actively participate in lessons and urging them to conduct researches, promoting exchange of ideas and communication, and improving problem-solving skills (Özmen, 2004). Considering its level of effect in teaching concepts, the positive contributions of the 7E model to the teaching process stand out (Kaleli-Yılmaz et al., 2010) and its use in teaching of physics is recommended (Demirezen, 2012; Gönen and Kocakaya, 2010; Kanlı, 2009; Ültay and Çalık, 2011). In terms of teachers, it is emphasized that the 7E model is easier to create and apply compared to the other models, and offers the opportunity to more effectively evaluate the students (Ültay and Çalık, 2011). Furthermore, the 7E model allows use of technology in the teaching process, making it easier for teachers and specialists to use at schools (Özmen, 2004). Difficulty of teaching the electricity and relevant concepts, which we use often in real life and start to be taught gradually from the first years of primary education, is frequently expressed in the literature (Ateş and Polat, 2005; Çıldır and Şen, 2006). It was stated in studies conducted that students develop misconceptions due to a variety of problems arising from teachers and students (Dilber and Düzgün, 2003; Frederiksen et al.,1999; Günbatar and Sarı, 2005; Küçüközer and Kocakülah, 2007; Lee and Law, 2001;Shepardson and Moje, 1994). In this context, it is seen that the electrical current, potential difference, circuit components and their characteristics are not accurately understood (Ateş and Polat, 2005; Narjaikaew, 2012; Shepardson and Moje, 1994). However, it is also emphasized that students had misconceptions such as 'if the switch is off, none of the light bulbs on the circuit will light' and 'light bulbs connected in parallel will produce more light than light bulbs connected in series' (Küçüközer and Kocakülah, 2007). Existence of differences in interpretation of concepts of physics by teachers and learners, problems in use of alternative measurement and evaluation methods, as well as challenges seen in laboratory applications in many schools (lack of required materials, non-affordability and dangerous nature of some experiments, etc.) negatively affect the quality of teaching (Redish, 1994; Gürdal and Yavru, 1998; Küçük et al., 2004; Günbatar and Sarı, 2005; Bozkurt and Sarıkoç, 2008; Örnek ewt al., 2008; Sağlam-Arslan et al., 2009; Tanel and Önder, 2010; Süzük et al., 2011). Furthermore, hours of study kept limited due to reasons such as lack of materials and inadequacy of laboratories often lead to performance of experiments with crowded groups or in the form of demonstrative experiments (Gürdal and Yavru, 1998; Tanel and Önder, 2010). It is emphasized that the misconception of students may not be corrected using conventional methods (Yiğit and Akdeniz, 2003; Tekbıyık and Sağlam-Arslan, 2008). In addition, it is also stated that students are unable to carry out appropriate experiments relating to specific subjects, due to the fact that they are inexperienced in using tools and equipment in an electronics laboratory (Tanel and Önder, 2010). Studies conducted in this field point out to prevalence of challenges encountered in teaching the "Electrical Circuits" subject. Particularly, the fact that the physics teachers also have considerable misconceptions with respect to the electrical circuits makes it even more challenging to teach this subject effectively (Küçüközer and Demrici, 2005). It is emphasized that the virtual laboratory software programs developed as an alternative in areas where experimental studies that are non-affordable, difficult and dangerous, are useful in teaching such a challenging and abstract subject, which is frequently encountered in real life, and at any level of education (Çıldır and Şen, 2006; Bozkurt and Sarıkoç, 2008; Tanel and Önder, 2010; Karakuyu and Tüysüz, 2011; Tatlı and Ayas, 2011; Narjaikaew, 2012). It is stated that these software programs developed as a reliable and ergonomic tool for performance of virtual experiments by students increase students' academic achievements and their motivation for the course (Kukkonen et al., 1997; Jimoyiannis and Komis, 2001; Moshelland Hughes, 2002; Karagöz and Özdener, 2007; Michelet et al., 2007; Tarekegn, 2009). Furthermore, teachers need such software programs while performing difficult experiments and activities relating to subjects that are challenging to teach. Nevertheless, because the studies that would provide guidance to teachers in use of virtual laboratory software programs effectively and correctly are limited, teachers are unable to use them effectively. In this case, it is considered required to develop effective virtual laboratory guidance materials for physics teachers, on the basis of the 7E model for the "Electrical Circuits" subject in the secondary grade of the high school education.

1.1. Conceptual Framework

The 7E model, and its stages, used in the course materials developed as a result of the literature review conducted in line with the purposes of the study are described below (Kanlı, 2009; Ültay and Çalık, 2011):

1. Engage: This is the stage during which it is endeavored to increase the interest and motivation of students, and it enables students to mentally focus on a problem, situation, and event.
2. Explore: This is the stage during which students use some skills by nature of scientific researches. Students are provided with time and place to carry out experiments, and given opportunity to develop concepts and skills.
3. Explain: Students work with others (classmates, teachers, etc.) to accept or reject a hypothesis they proposed. Teachers provide scientific explanation taking into consideration the models developed by students.
4. Elaborate: This is the stage where students test their conclusions through which they arrive at a different event by means of smaller experiments in addition to the activities/experiments conducted. This process provides students with the chance to improve their knowledge of concepts, and apply it to other contexts.
5. Extend: Students are asked to relate the existing concepts with other areas of real life and/or with other concepts/subjects to transfer the knowledge and skills they acquired.
6. Exchange: Students are asked to present the data, graphs, examples, etc. about the experiment they previously shared with their group-mates to other students, and to discuss them.
7. Evaluate: Students attempt to find answers to different questions based on data and evidences, considering the concepts they acquired during application. Teacher evaluates students more formally. It is important that students receive feedback.

The activity prepared within the framework of the 7E learning model and using the virtual laboratory software program is provided in the Appendix 1. Context-based learning approach is used in the process of development of secondary education physics curricula in Turkey. However, teachers and researchers familiar with the 5E and 7E models face a dilemma when they encounter context-based learning, and particularly REACT strategy (Ültay and Çalık, 2011). Furthermore, plentiful features and details in the explanation and evaluation steps of the 7E model increase the effectiveness of the curriculum. Even though there are many studies in the literature stating that both the 7E learning model (Kanlı, 2009; Ültay and Çalık, 2011) and the virtual laboratory software programs (Kukkonen et al., 1997; Jimoyiannis and Komis, 2001; Moshell and Hughes, 2002; Karagöz and Özdener, 2007; Michelet et al., 2007; Tarekegn, 2009) are effective in the teaching process, inadequacy of exemplary course materials supporting combined use of the 7E learning model and virtual laboratory software programs and providing guidance to teachers requires development of such materials. This study conducted on this basis will investigate the "Electrical Current and Circuits" subject of the "Electricity and Magnetism" unit included in the secondary education 10th grade physics course, by developing a teaching material based on the 7E model in the virtual laboratory environment.

2. Purpose

The purpose of this study is to develop a guidance material for teachers based on the 7E model in the virtual laboratory environment for the "Electrical Current and Circuits" subject of the "Electricity and Magnetism" unit included in the physics curriculum for the secondary grade of high school, and to evaluate the same based on the opinions of teachers and specialists.

3. Method

The special case method is used in this study. Firstly, a research was conducted on virtual laboratory software program and the teaching methods used in teaching of physics within the scope of this method, and upon choosing the 7E learning model, other studies (about 7E learning model) in the literature were reviewed. In this context, the teacher guidance material designed for the "Electrical Circuits" subject was prepared taking into consideration the opinions and recommendation of physics teachers and specialists. The opinions of specialists in the field of teaching of physics and teachers working in the secondary education on the application conducted were acquired by means of semi-structured interviews and using a "Course Material Evaluation Scale" (Kurnaz, 2011), whose validity and reliability were confirmed.

3.1. Sample

The sample of the study was composed of 4 physics education specialists (lecturers) working at the Karadeniz Technical University (KTU) Fatih Faculty of Education, 1 specialist who completed a PhD program in the field of physics education, 6 physics teachers working at a number of high schools in the Istanbul province, and 1 electricity course teacher. 2 of the physics teachers that participated in the study serve at Anatolian High Schools, while 4 of them server at Public High Schools (Table 2). Characteristics of the physics education specialists, who participated in the study, are provided in Table 1.

Table 1: Characteristics of the Physics Education Specialists

Specialists	Gender	Title
S1	Male	Prof.Dr.
S2	Male	Ass.Prof.
S3	Female	Ass.Prof.
S4	Male	Dr.

Table 2: Characteristics of Teachers Included in the Sample (P: Physics Teacher, E: Electricity Course Teacher)

Teachers	Gender	Age	Tenure of Office
P1	Female	45	23
P2	Female	47	20
P3	Female	30	6
P4	Male	39	15
P5	Female	42	20
P6	Male	45	22
E	Male	38	15

All teachers that participated in the study were trained on use of the virtual laboratory software program, and briefed on the application and the teacher guidance material developed, and finally their opinions were obtained through semi-structured interviews.

3.2. The Virtual Laboratory Software Program Used in the Study

As a result of the research conducted taking into consideration the purpose of the study and the sample, it was decided that the "Edison 5" software would be appropriate. The software programs, is developed by the Designsoft company, and is a licensed (shareware) software program providing virtual laboratory environment for the

"Electrics-Electronics" subjects included in the secondary and higher education physics curricula. Users are allowed to drag required objects included in the program and drop them on the experiment field located on the right hand side of the screen using the mouse, and to combine them by making required adjustments (rotating, changing values, etc.). The program is able to create graphs for variables, and has 3D image capabilities. Furthermore, it is recommended by the Turkish Ministry of National Education.

3.3. Data Collection Tools

A semi-structured interview and a course material evaluation scale consisting of 36 items were used as data collection tools in the study. While preparing the scale, similar studies were reviewed and classified under two main titles: 1) Structural evaluation, 2) Contextual evaluation (Küçüközer and Demirci, 2005; Kurnaz, 2011). Findings from the interviews conducted to obtain opinions of specialists and teachers on the material designed were evaluated through descriptive analysis.

3.4. Process of Development of Materials

"Electricity" subject is chosen for this study on the basis of three reasons: 1) Considerable emphasis is laid upon the concepts of "Electricity" in the national and international literature, 2) These concepts form the basis of many physics concepts and of real life, 3) Because the physics curriculum has a convoluted structure, concepts of "electricity" are studied in more details in future grades. The following stages were followed in the design process of the material:

1. Selection of subject, and identification of acquisitions.
2. Identification of the appropriate learning model.
3. Selection of the appropriate virtual laboratory software.
4. Conducting literature review relating to the 7E learning model.
5. Preparation of activities with contents connected with the virtual laboratory software, conforming to the 7E learning model, considering the acquisitions related to the subject.
6. Obtaining opinions of specialists and teachers.
7. Designing the teacher guidance material based on the stages of the 7E model, indicating the instructions for teachers relating to the respective stages inside frames and in italic type.
8. Making the teacher guidance material feasible in line with the opinions of specialists and teachers.

The "Electrical Current and Circuits" subject included in the "Electricity and Magnetism" unit of the 10th grade physics course consists of three acquisitions, and all three acquisitions were considered in the material developed. The characteristics of the activities included in the teacher guidance material developed based on the stages of the 7E learning model are provided in Table 3.

Table 3: Characteristics of the activities included in the material developed based on the stages of the 7E learning model

Stages of the 7E Learning Model	Reflections on the Teacher Guidance Material	Activities for which Teachers are Responsible	Use of the Virtual Laboratory Software in the implementation stage of the model
Engage	Consists of three sections: 1) Do we know these? 2) Let's think 3) Look and try to see	• Questions based on texts and pictures that enable realisation of the incidents we frequently see in real life are asked. • Students are enabled to share their knowledge in the classroom environment. • Questions that will reveal deficient or incorrect opinions of students are asked and recorded.	• Rather than getting students engaged in application, teacher can show example circuit drawing if he/she considers required.

Explore	• Identification of variables • Proposing hypotheses • Stating the names, symbols and shapes of the components in a simple electrical circuit • Carry out experiments • Keeping records of the experiments • Opinions of students relating to the data obtained as a result of the experiment set-ups they designed according to the hypotheses they proposed are recorded.	• Hypotheses proposed by students are not corrected. • Contributions are made by means of questions and answered to provide guidance to students without revealing the correct answer. • Guidance is provided to students as necessary. • Students are assisted through discussions and directions, rather than revealing the correct answer.	• Students are asked to create the shapes relating to the example experiment sets included in the course material using the virtual laboratory software. • This is the stage where the virtual laboratory software will be used intensively. • Students are allowed time to create experiments different from the example experiment set-ups included in the course material.
Explain	• A graph is drawn based on the data obtained from experiments, and calculations are done. • Hypotheses proposed are interpreted. • Conclusion is drawn based on the data obtained from the experiments.	• Students are given instructions to enable them to draw a graph, without revealing what graph is to be drawn, and to comment on the graph they drew.	• It plays an important role in identification of data to be obtained from the experiment set-ups created using the virtual laboratory software. • Students are provided with assistance in doing calculations relating to the data obtained from experiments, and in creation of graphs.
Elaborate	• Activity for application to different situations	• Students are asked to find answers to questions considering data obtained as a result of the applications carried out.	• An electrical circuit with rheostat is created using the virtual laboratory software • Values of variables are identified quickly using ammeter and voltmeter and recorded on a table.
Extend	• Correlation of knowledge obtained with situations encountered in real life	• Guidance is provided as necessary to enable students to solve a given problem.	• The electrical circuit included in the problem given is created using the virtual laboratory software.
Exchange	• Sharing the knowledge obtained from the activities with the classroom	• Listens to opinions of students, and enables them to present the data obtained, creating the environment for relevant discussions among students • Provides guidance to prevent shifting of subject to irrelevant subjects.	• Results of students having different opinions are tested using the virtual laboratory software.
Evaluate	• 4 open-ended questions are asked for evaluation of what have been learned	• Comments of students are obtained regarding the experiments conducted using the virtual laboratory software, to check whether they learned correctly.	• Students attempt to reach the result using the virtual laboratory software for subjects and questions they did not understand.

4. Findings

The findings obtained from the scale applied to specialists and teachers, and from the interviews conducted with teachers within the scope of the study are presented under the following subheadings:

4.1. Findings Obtained from the Course Material Evaluation Scale:

The course material evaluation scale used in the study consists of two parts, and questions and averages relating to each stage are separately shown in Table 4 and Table 5. The specialists were requested to present their recommendations and critiques while expressing their opinions with “Positive” or “Negative” in their evaluations. Teachers were requested to evaluate the items of the scale with “Yes”, “Partially” and “No”. Furthermore, a blank space is provided for teachers to indicate the items they commented with “Partially” and “No” and to express their grounds for that comment. While the responses were being assessed, “2 points” were given for “Yes”, “1 point” for

"Partially", and "0 point" for "No". Teachers were asked to explain their comments during the interviews conducted after assessment.

Table 4. Comments made relating to the structural evaluation included in the Course Material Evaluation Scale and their averages

Structural Evaluation				
Expressions		Opinions of specialists	P Opinion Average	E Comment
Course material prepared …	Appropriate and comprehensible for 10^{th} grade students.	Positive	1.67	1
	Covers the acquisitions relating to simple electrical circuits	Positive	2	1
	Aimed at teaching the concepts relating to simple electrical circuits	Positive	2	2
	It is convenient for studying in 2+2 course hours (for a class having 2 hours of physics course a week).	Negative	1.67	2
	Things required to be done in each stage covered are appropriately specified	Positive	2	2
	It can be conveniently used within the classroom	Negative	1.83	2
	Language of ….. is comprehensible.	Positive	1.83	2
	Activities included in the … are comprehensible.	Positive	2	1
	Pictures included in the … are convenient and comprehensible.	Positive	1.83	2
	Layout and order of the tables included in the ….. are convenient.	Positive	2	2
	Colours and graphs used in the ….. are suitable for the level of students.	Positive	1.83	2
	Instructions include in the …. are comprehensible.	Positive	2	2
	The virtual laboratory software used in the … is effectively used in all activities.	Positive	2	1
	The virtual laboratory software used in the … is appropriate of the level of students.	Positive	2	1
	The graphs included in the virtual laboratory software used in the … are appropriate for the level of students.	Positive	2	1
	Example experiments included in the virtual laboratory software used in the … are appropriate for the level of students.	Positive	2	1

As can be seen in Table 4, while the physics education specialists expressed positive comments, they made recommendations on some expressions and tables. Furthermore, they drew attention to insufficiency of the time planned for practicing all activities, stating that number of questions included in the material developed ought to be reduced. Accordingly, deficient or incorrect expressions were corrected, and it was stressed that it would be convenient to provide plotting space in the field where students are required to draw a graph, and that it was necessary to make it clear and comprehensible for teachers what specific acquisitions were taken into consideration in preparation of each stage. Even though the average of the responses given by physics teachers with respect to the structural content was 1.89, the average of the responses by the electrics teacher was 1.56. When the data obtained from the scale are examined, it can be seen that it is positive in structural terms. The physics teachers had different opinions about the application time for the material developed. The physics teachers serving at the Anatolian High Schools found the time planned acceptable, while those serving at public high schools were of the opinion that the time given was not sufficient for many students to comprehend and perform the requested practices. Therefore, the activity developed can demonstrate flexibility depending on the student profile. On the other hand, the electrics teacher found the time given adequate, and was of the opinion that the number of mathematical expressions in the activities should be increased.

Table 5. Opinions relating to the contextual evaluation included in the Course Material Evaluation Scale and their averages

Contextual Evaluation			
Expressions	Opinions of Specialists	P Opinion Average	E Comment
Motivates students toward the subject.	Positive	2	2
Adequate to elicit the preliminary knowledge of students.	Positive	2	2
Activities included in the … conform to the acquisitions.	Negative	2	1
Activities included in the … are appropriate for level of students.	Positive	1.83	2
Examples included in the … are related to the examples from the real life.	Positive	2	2
Guides students toward critical thinking.	Positive	2	2
Guides students toward explorations and investigations.	Positive	2	1
Contains activities to enable students to evaluate themselves.	Positive	2	2
Organized in conformance to the 7E learning model.	Negative	2	2

Course material prepared …	Includes activities covering the first phase of the 7E learning model: “Engage”.	Positive	2	2
	Includes activities covering the second phase of the 7E learning model: “Explore”.	Positive	1.83	2
	Includes activities covering the third phase of the 7E learning model: “Explain”.	Positive	2	2
	Includes activities covering the fourth phase of the 7E learning model: “Elaborate”.	Positive	2	2
	Includes activities covering the fifth phase of the 7E learning model: “Extend”.	Positive	2	2
	Includes activities covering the sixth phase of the 7E learning model: “Exchange”.	Positive	2	2
	Includes activities covering the seventh phase of the 7E learning model: “Evaluate”.	Positive	1.83	2
	Order of activities included in the… is provided correctly to enable students to lead to the result.	Negative	2	1
	The virtual laboratory software program used with the. … provides students with the trial and error opportunity.	Positive	2	2
	The virtual laboratory software program used with the. … provides assistance to do calculations relating to the circuits created.	Positive	2	2
	The virtual laboratory software program used with the. … is used for all experiments.	Positive	2	2

The averages related to the contextual findings included in the Table 5 are 1.97 for physics teachers and 1.85 for the electrics teacher. This difference in scores arises from the opinion of the electrics teacher that more problems containing mathematical operations should be included. On the other hand, number of mathematical operations were reduces in the new physics curriculum developed based on the constructivist approach. Consequently, it was seen that the teachers that participated in the study had positive opinions regarding the course material developed. The specialists that participated in the study expressed positive opinions regarding the contextual evaluation, but they stated that the number of items should be increased with respect to the 7E learning model. Therefore, it is seen that they generally had a positive conclusion in comments made with respect to the each phase and in the activity developed in line with these phases. It was emphasized that the activities included in the material were inadequate in terms of use and their correlation with each other. Particularly, it was stated that the number of questions included in the first phase of “Engage” was very high, and therefore they took unnecessarily long time. For this reason, questions relating to the activities were removed from the material, and the question included in the “Let’s think” section was amended.

4.2. Findings Obtained from Interviews:

Opinions of physics teachers working at high schools regarding the teacher guidance material developed in this study are provided in this section. The teachers coded P1, P3 and F4, working at a public high school stated that the material developed could be partially applied, and that the time given was insufficient. The teacher coded P2 stated that the time was extremely insufficient, and that it would not be possible to complete the activities in a timely manner. Even, teacher P2 said *“4 hours would be insufficient, it should be 8 hours”.* Teachers P5, P6 and E found the time given sufficient. Teachers P1, P3 and P4 stated that they found the language used in the material was extremely academic. Furthermore, they said more real-life pictures relating to the subject could be used, and simpler activities should be used. P1, P2, P3 and P4 stated that the activities planned using the virtual laboratory software and the problems given were rather difficult. Teacher P1 said, *“….simpler activities can be used… “*; Teacher P4 said, *“Even I would have difficulties in solving some problems included in the material. We explain them on a simpler level during the lessons. Level of students is extremely low, and they do not understand anyway…”*. Teacher E said, *“The electricity should be explained taking into consideration not only the mathematical but also behavioral factors as well. Otherwise, incorrect inferences would be made. Furthermore, more interdisciplinary relations should be established while explaining the electricity subject”*. Even though all teachers included in the sample had positive opinions regarding use of virtual laboratory software within the framework of the activities included in the teacher guidance material developed, they expressed their concerns regarding that the lessons are required to be taught not in the classroom but in the IT (Information Technologies) classrooms at schools. The reason is that, teachers are used to teach in the classroom environment, and they have concerns due to any problems (e.g. classroom management, course presentation, technical problems, etc.) that may occur during lessons. Therefore, they state that assistance would need to be sought from the IT teachers serving at schools. During the interviews, it was also observed that the physics teachers did not have the knowledge and experience on how to use the virtual laboratory software during lessons and how to provide guidance to students. For this reason, the teacher guidance material developed drew considerable attention. Teacher “E” expressed positive opinion on performance of the application in the IT classroom or at the electricity workshop. The electrics teacher experienced in teaching in the laboratory and workshop environments seemed to be more courageous compared to physics teacher with regard to application of the teacher guidance material. Although all teachers that participated in the study stated that students would also be pleased with the application of the virtual laboratory-aided activity prepared in accordance with the 7E learning model, and that it would ensure more permanent learning, they said they would apply the methods they were used to apply due to the insufficiency of time and their lack of knowledge and experience in that respect.

5. Discussion And Conclusion

It was seen that the specialists had positive opinions while evaluation the teacher guidance material developed. The physics and electrics teachers serving at secondary education level also emphasized that the material developed was appropriate in terms of the structure and contents. It has been concluded that the teacher guidance material developed taking into consideration the data obtained could be used for the “Electrical Current” subject in the 10^{th} grade physics course. Based on the semi-structured interviews conducted within the scope of the study, in spite of the positive opinions of the physics teachers, the requirement to use computer and IT classrooms due to utilization of the virtual laboratory software included in the classroom activities lad to concerns in them. On-the-job training is required in this respect to eliminate these concerns of physics teachers. Teachers should be given on-the-job-training particularly in fields, such as the electrical circuits, where there are considerable misconceptions (Küçüközer and Demirci, 2005). It is emphasized that virtual laboratory software programs are needed for a subject like electricity, a concept which is frequently encountered in real life and is challenging to learn and teach (Karagöz and Özdener, 2007; Bozkurt and Sarıkoç, 2008). But the physics teachers serving at high schools see themselves inadequate in this respect. Both their motivation and their positive views on use of such software programs decreases against this situation, which they are not familiar with. Therefore, virtual laboratory software programs should be introduced to teachers, training should be provided on their use, and their utilization in many subjects included in the curriculum should be promoted. Therefore, studies with theoretical and practical contents are needed to show use of the virtual laboratory software based on a specific teaching model. The physics teachers working at a public school stated that there were excessive activities and the language used was extremely academic, while teachers working at an Anatolian High School said the material developed was convenient. It would be more convenient if teacher guidance materials and course activities developed taking into consideration the above situation were appropriate for the level of students, and if specialists and teachers prepared flexible course materials. Although all teachers that participated in the study thought that the teacher guidance material developed would be effective in terms of both teachers and students, they rather abstained from using it due to reasons such as their inexperience in use of virtual laboratory software, concerns relating to catching up with the curriculum, physical conditions of schools, conducting lessons in IT classrooms, going beyond the standards they are accustomed with, and their misconceptions relating to the subject. Therefore, schools should improve their IT classrooms and install virtual laboratory software programs on all computers, and physics teachers should be encouraged to use them. It is known that many problems are encountered in laboratory applications for courses such as physics, in which laboratory studies are important (Tekbıyık and Sağlam-Arslan, 2008; Tanel and Önder, 2010). Quality of the physics education decreases due to reasons such as lack of materials, insufficiency of laboratories, non-affordability and dangerous nature of some experiments, etc. (Gürdal and Yavru, 1998; Küçük et al., 2004; Günbatar and Sarı, 2005; Bozkurt and Sarıkoç, 2008; Süzük et al., 2011). Taking all these problems into consideration, it could be ensured that the IT classrooms at high schools to be used more actively. Thus, students could be given the opportunity to conduct unlimited experiments safely, fast and economically. The virtual laboratory software programs should also be used in other courses such as chemistry and biology that require laboratory applications. Furthermore, their influences on students and teachers should be studied using them in conjunction with the other learning models. Such studies are important in terms of concrete application of the teaching theories developed and of acceptance of such theories by parties assuming role and responsibility in education of teachers. In this context, it is considered that the example activity offered within the scope of this study would provide benefits and guidance to physics teachers and light the way for further studies to be conducted in teaching of physics.

Appendix: Teacher Guidance Material Developed based on 7E Learning Model in Virtual Laboratory Environment

Recommended duration: 160 minutes. (2+2 course time)

Acquisitions: Students analyse the relations among the concepts of current, resistance, and potential difference.

1. Students are enabled to create the mathematical model of the relations among current, resistance, and potential difference by carrying out experiments on simple circuits.
2. Students solve problems relating to the concepts of resistance, potential difference and electrical current in simple electrical circuits.

Lesson 1:

1. Engage Phase:

- *This phase should be handled in 3 sections (A- Do we know these?, B- Let's think, C- Look and try to see).*
- *A number of questions are asked to students in connection with the previous phase at each phase.*

Guidance: *The following questions are asked to students prior to starting the subject to enable them to express their thoughts (Recommended duration: 20 minutes).*
A. Do we know these?: This is the activity aiming to measure the prior knowledge of students and to reveal their misconceptions. Prior knowledge of students is noted.
B. Let's think: It aims to create a conceptual contradiction with the existing prior knowledge of students.
C. Look and try to see: Students attempt to carry out trials in the classroom to solve a problem given in the question before starting the activities.

A number of electrical appliances are plugged in and out to observe whether the light bulb would produce more light. Relevant opinions of students are noted.

A. Do we know these?

- We can operate both a washing machine and a dishwasher simultaneously at home, and we can do ironing while watching TV. How do you explain this?
- In how many ways can the electrical appliances be connected to the mains? Do these ways of connection also apply to resistors?

B. Let's Think!

- Some of the appliances located in the same room may be on and some may be off. When all of them are operated simultaneously, how would the electrical appliances be affected by this? Would any additional electrical appliance have any effects on other appliances?

C. Look and Try to See!

- How other electrical appliances are affected if we turn on and off some electrical appliances in our homes? For example, how would a refrigerator, which runs continuously, be affected if we turn on the oven in the kitchen? How can you test it using other electrical appliances? Write what you learn and think.

2. Explore Phase:

- *Students are allowed to identify the variables, propose hypotheses, carry out experiments, and test and correct their hypotheses.*

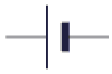
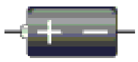
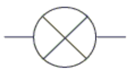
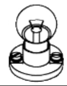
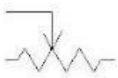
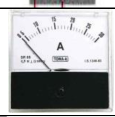
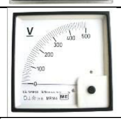
Guidance: *By nature of scientific researches, students can test their prior knowledge, which they expresses within the classroom before starting the activities, using the virtual laboratory software. It is not necessary that the hypotheses proposed by students are scientifically correct. They will themselves see whether their hypotheses were correct or not at the end of the activities. Students are requested to identify the variables prior to proposing their hypotheses. Accordingly, the responses expected for the activities included in the students' worksheets are provided in Table 1 and Table 2 (Recommended duration: 20 minutes).*

Table 2. Types of variables included in the hypothesis

	Status 1	Status 2
Independent variable:	Number of bulbs	Number of batteries
Dependent variable:	Brightness of bulb	Brightness of bulb
Controlled variable:	Number of batteries	Number of bulbs

Students begin to use the computers, which have the virtual laboratory software, in the computer classroom in groups of two. While proposing their hypotheses, students may be assisted by way of a number of questions and directions related to the subject.

Table 3. Names, symbols and shapes of the circuit components included in the electrical circuits subject

Name	Symbol	Shape
Connection cable		
Battery		
Bulb		
Resistance		
Rheostat		
Circuit breaker		
Ammeter		
Voltmeter		
Receptacle	-	

Battery bed	-	

D. <u>Time for Exploration!</u>

Prior to designing the experiments, share your knowledge by following the steps below:

Step 1. Identify the variables: What can be the variables in this experiment?	
Independent Variable:	
Dependent Variable:	
Controlled Variable:	
Step 2. Form your hypothesis sentence: What is/are the hypothesis/hypotheses you can propose in this experiment?	
Hypothesis 1:	
Hypothesis 2:	
Hypothesis 3:	

Write the names, and draw the symbols and shapes of the circuit components in a simple electrical circuit.

Name	Symbol	Shape

<u>Lesson 2:</u>

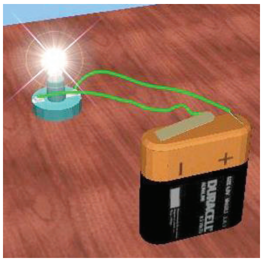
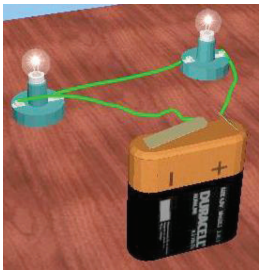
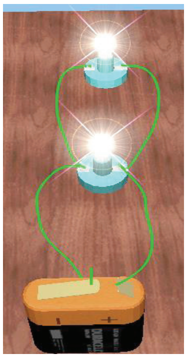
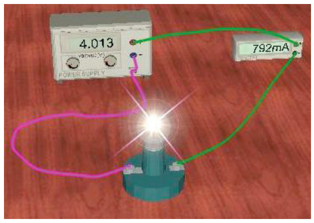
2. Explore Phase:

- *Students are allowed to test their hypotheses using the virtual laboratory software programs. This stage may sometimes take a long time.*
- *Teachers should contribute to the process by asking questions and providing guidance without revealing the correct answer.*

Guidance: *Students are asked to create the example circuits shown on their worksheets using the virtual laboratory software, and save them on their computers (Recommended duration: 40 minutes).*

- Combine the electrical circuit components in a variety of ways using the virtual laboratory software.
- Connect multiple light bulbs and resistors in a number of ways considering the examples shown below.

- Do not forget to connect an ammeter and a voltmeter to the electrical circuits created.

- Note down the values shown on the ammeter and voltmeter for the respective electrical circuit created.
- Do not forget to save the experiment setups created using the virtual laboratory software on your computer.

Potential Difference (V)	Current (A)	V/I

Make projections: If your hypotheses are correct, what projections can you make?
....
....

Lesson 3:

3. Explain Phase:

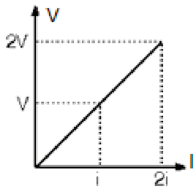
- *Students are asked to draw a general conclusion using the data they obtained in the previous stage.*
- *They are asked to obtain various data from the experiment setups they created, and then create graphs and do calculations.*
- *As a result of all these applications, students will have a general conclusion with respect to the subject, and they test the hypotheses they proposed earlier.*

Guidance: *Students open the experiment files they created and saved using the virtual laboratory software during the previous lesson, and write down the values shown on the ammeter and voltmeter in the table on their worksheets. They do mathematical calculations and draw graphs based on these data. They should not be told what graph they should draw. Students are asked to comment on the dependent and independent variables they identified. Guidance may be provided if deemed required. They are told that they should make required arrangements by comparing the data they obtained with their hypotheses. The result they will obtain from all these applications and calculations will lead them to the "Ohm's Law". Guidance may be provided to students as necessary, but the result must never be revealed (Recommended duration: 20 minutes).*

- Draw a graph for different current and potential difference values on a circuit you will create using the virtual laboratory software.

Draw a graph
Calculations:

Answer: *A graph similar to the one shown here, based on the R=V/I formula.*



Comment on your hypotheses using the calculation on the graph.
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Draw a Conclusion: What conclusions can be drawn also considering the previous experiments?

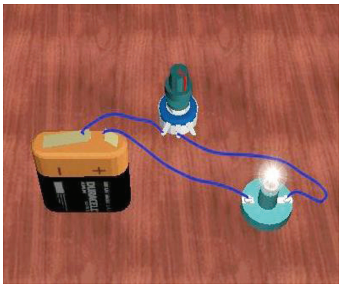
Conclusion-1:	
Conclusion-2:	
Conclusion-3:	

4. Elaborate Phase:

- *This is the stage where students test their conclusions through which they arrive at a different event by means of smaller experiments or thought experiments in addition to the experiments conducted.*
- *This process provides students with the chance to improve their knowledge of concepts, and apply it to other contexts.*

Guidance: *Students are asked to create an experiment setup similar to the one previously created using light bulbs and resistors, but this time using a rheostat, and to compare the results (Recommended duration: 20 minutes).*

Time to Apply to Different Situations



An example electrical circuit created using a rheostat is provided in the figure shown on the left/right hand side. Now create a similar experiment set-up, and note the potential difference and electrical current values for a number of rheostat values in the following table.

V (Potential Difference)	I (Current)	V/I

What your opinions about the relation between the potential difference and electrical current values you obtained from the electrical circuit you created using a rheostat? What are the similarities and differences with the circuits you created without using rheostat?
....
....
....

Lesson 4:

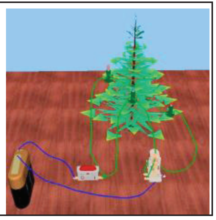
5. Extend Phase:

- *Students are requested to correlate the existing concepts with other areas in real life and/or other concepts/subjects for transferring the knowledge and skills they acquired.*

Guidance: *The following example question is asked to motivate the students to conduct researches on a subject they see in real life. Each group independently seeks an answer to the question (Recommended duration: 20 minutes).*

Time to Relate

You must have seen the flashing lights on Christmas trees. How do you think this many lamps are connected? How can they flash? Can you explain?



....
....
....
....

Answer: *Because, all LED lights used for decorating. Christmas trees do not turn and on and off simultaneously, we can say that they are connected in parallel.*

6. Exchange Phase:

- *Students exchange the data they obtained from the experiments with their group-mates at the end of their previous experiments.*
- *They present the graphs, examples, etc. to each other and discuss them.*

Guidance: *Students are asked to discuss the data and results they obtained from the previous experiments they conducted within the classroom. They are requested to discuss them within the group for 5 to 10 minutes first and then in the classroom environment, and to give examples of different situations they encounter in real life. As a good listener, the teacher listens to the discussions without interfering in them, unless they go off the subject, and provide guidance as necessary (Recommended duration: 20 minutes).*

Time to Share

Share the conclusions you drew from the experiments with your classmates. Write about your thoughts about other application in real life, by dicussing with your other classmates.

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7. Evaluate Phase:

- *Students attempt to find answers to different question based on the proofs and evidences in the light of the concept they acquired during the application.*
- *The teacher must provide a feedback taking into consideration the data obtained from students.*

Guidance: *First of all, students are asked to find answers to the questions on their worksheets with respect to the experiments they conducted. Then, any points not understood or misunderstood can be reviewed and summarized within the classroom. Students are asked to find answers to questions by discussing in the classroom. The teacher confirms the correct ones after receiving the answers from the students, and make explanations based on the respective experiment files in case of incorrect answer (Recommended duration: 20 minutes).*

I am evaluating the things I have learned

- Answer the following questions using the knowledge and skills you have acquired from the experiments you conducted using the virtual laboratory software.

Guidance: *The answers expected to be given by students to question on the worksheets are provided in the following table.*

Question 1:	**How should you connect a light bulb to make it shine?** *The light bulb shone when we created closed circuits in parallel or series.*
Question 2:	**What magnitude did the curves of the graphs you drew give?** *The curve of the line on the potential difference and current graph (V/I) gave the "resistance". It was seen that the proportion of V/I was fixed in the experiment setups created. And this led us to the Ohm's Law.*
Question 3:	**Should your graphs have passed through zero? Why/Why not?** *If the potential difference in a circuit is "0", then the current is "0" too. Therefore, it should have passed.*

Question 4:	**<u>Is the V/I value fixed for each experiment setup? Why/Why not?</u>** *As per the Ohm's Law, in all electrical circuits where the resistance is fixed, the V/I proportion is fixed and is shown with the letter "R".* *Because the resistance varies in circuits with rheostats, the V/I proportion will also vary.*

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