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Material design based on 5E Learning model on physics laboratory applications

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Abstract

The aim of laboratory is to teach research and observation skills and techniques, develop problem-solving skills and scientific searching methods, and to help students develop a positive attitude towards these studies (Kurt et al., 2002). Nuhoglu and Yalcin (2004) have suggested that permanent learning can be achieved through effective science teaching which will help would-be teachers develop positive attitudes towards laboratories encouraging their interest. As a result of these researches, some changes have taken place in education applications. A transition from traditional teaching methods in which teachers play an active role into student-centered restructuring in which students can restructure information themselves is taking place. Moving from that fact, it is aimed to study the effects of the materials developed according to the 5E Learning Model in General Physics laboratory on students' acquisitions. In addition to contributing to the literature about Physics education and teaching, the study will have evaluated the effectiveness of the materials developed according to the 5E model in mechanical terms and the applicability of the model.

Keywords: Physics education, 5E learning model.

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1. Introduction

It is no longer sufficient transferring knowledge, beliefs and emotions directly to the individuals for a society to level of modern societies (Ayaz, 2015). One of the most effective teaching models in modern education is constructivism (Biber, Tuna, Gülsevincler & Karaosmanoglu, 2015). The basis of constructivist approach is suggesting that people should construct their knowledge by themselves rather than receiving them directly from others (Ayvaci & Bakirci, 2012). According to Moussiaux & Norman (2003), constructivism is based on an idea of constructing personal and individual knowledge rather than reproducing others' knowledge (Biyikli & Yagci, 2015).

The effect of constructivist approach to the field of science is quite important. One of the implementation of this theory in science education is 5E Learning Model developed by (Bozdogan & Altuncekcic, 2007; Keser, 2003; Yenilmez & Ersoy, 2008). 5E learning model consists of five stages: Engage, Explore, Explain, Elaborate and Evaluation (Cepni, Akdeniz & Keser, 2000; Bybee & Landes, 1988; Bybee et al., 2006; Eisenkraft, 2003). 5E learning model provides requirements of constructivist approach giving students the ability of exploring concepts, explaining these concepts and giving them the opportunity to practice on these new concepts (Pabuccu & Geban, 2015). 5E Instructional Model provides students to learn new concepts or understand a known concept in detail. This process is a linear process. Students should use their prior knowledge while exploring new concepts to add meaning to these concepts (Ergin, Kanlı & Tan, 2007).

In this study, it was aimed to develop materials according to the 5E learning model to be used in physics laboratory exercises. This study will contribute to the literature about physics education and applicability of the model will be tested by developing materials that fit 5E model.

2. Method

In this part of the report, we will discuss the development of guidelines that will be created within the scope of the study.

2.1. Preparation of experiment guidelines

In this part, information will be given about teaching method applied on experiment groups and development stages of experiment sheets containing the stages of 5E learning model will be presented.

2.2. Applications performed in the stage of engaging

Interesting information are given or interesting stories were told to the students about daily use of experimental subjects in the engaging stage of the experiment reports in order to make an exciting introduction that will attract attention of students about the experiment. The part of "What do you know" was prepared to let them think about the experiment and present their knowledge about the subject. In this section, interesting questions were asked and attention of the students was tried to be attracted. The purpose of these activities is increasing interest and motivation of the students. This stage is considered successful if some questions such as "What do I know, why this happens and what can I do?" come to the minds.

WHAT DO YOU KNOW?

- Is it simple harmonic motion if a soldier guarding the palace gate is walking back and forth regularly?
- Does a pendulum clock lose or gain time if it is taken from sea level to top of a mountain?
- Is it possible to measure the length of a simple pendulum by using a stopwatch? How?

Figure 1 Introduction part of an experiment, what do you know?

In some experiment reports, in the introduction section, interesting pictures was used about the subject and interesting analogies are given and an issue or observation from daily life is presented and the attraction of students is tried to be grabbed by asking some questions about these.

In the section of focusing on thinking, students were allowed to discuss ideas with each other and they were asked to produce relevant ideas and create experiments to solve the problem.

<p>FOCUS ON THINKING:</p> <p>How would you design an experiment if you were asked to design a simple pendulum?</p>

Figure 2 Introduction part of an experiment, the part of focus on thinking

2.3. Applications performed in the stage of exploring

After attracting attention of students in the phase of introduction of the study, they were asked to identify the dependent, independent and control variables in the experiment. They will present all the factors that may affect the experiment when they identify these variables. This phase is the phase containing the maximum rate of student activities. Explore stage is divided into 5 sections while experiment reports are being prepared. These sections are as follows:

<p>B-EXPLORING TIME</p>
<p>Please follow the sequence for the experiment you have designed.</p> <ol style="list-style-type: none">1. Set variables2. Create your hypothesis3. Prepare the experiment setup4. Make predictions5. Record the data

Figure 3 Exploring phase of a sample experiment report

Set the Variables: There are many variables that affect events in general. If we want to find the exact reason of a result that we have observed or we are curious about the result of a change, we have to identify the variables other than the variable in question and control them (Bagcı Kılıc, 2003). There are three kinds of variables in a scientific study. Independent (will be changed) variable is a factor or condition changed deliberately by researchers in an experiment. Dependent variable is a kind of “result” and it is the case needs to be explained by the researcher. The dependent variable is selected by researchers and the information collected about this variable is expected to shed light to the solution of the problem. The variables held constant throughout the study called control variables. There may be multiple control variables in an experiment. One variable should be changed deliberately at a time in order to achieve the objective and all other variables should be kept under control. If multiple variables are changed at a time, the results of the experiment cannot be interpreted in a reliable way (Temiz & Tan, 2009).

Students created hypothesis sentences, which will be tested later, in accordance with the variables identified.

1- Set the Variables	
What are the variables that can be used in this experiment?	
Independent Variable:	
Dependent Variable:	
Control Variable:	

Figure 4 Setting the variables in the explore section of a sample experiment report

Create your hypothesis: Hypotheses are educated and estimations that are created based on information obtained as a result of an experiment, which seems like approximation, but more formal and controlled. The hypothesis is not necessarily true. After creating the hypothesis, it should be tested. This is possible by designing an experiment. All variables except two of them should be under control in order to determine the relationship between these two variables (Bagcı Kılıc 2003).

2- Create your hypothesis	
What are the hypothesis/hypotheses that you can create in this experiment?	
Hypothesis-1	
Hypothesis-2	
Hypothesis-3	

Figure 5 Creating the hypothesis in the explore section of a sample experiment report

Prepare your experiment setup: In this phase of the experiment, the hypothesis created is tested to see whether it is true or not by changing the variables within the experiment setup prepared with necessary tools and devices. In this step, students are allowed to perform experiments on their own and be in direct relationship with experimental materials and tools. In this way, they experience their knowledge about the subject. In this phase, students were asked to test their hypothesis to see whether it is true or not by changing the variables within the experiment setup prepared with necessary tools and devices.

3- Prepare the Experiment Setup
Prepare the experiment setup by using the metal rod, tripod, joining piece, a small hooked ball, light mass rope, angle gauge, meter and stopwatch by yourself. Discuss with your group friends.

Figure 6 Establishing an experiment setup and performing the experiment for a sample experiment report

Make predictions: Prediction is forecasting outcomes of an event by using the data we have or our earlier experiences. They can be either correct or incorrect; the event may result as expected or unexpected, however, prediction is a skill that has to be developed in students (Bagcı Kılıç 2003). Students were asked to make predictions about the experiments they have prepared so they can interpret whether their predictions are correct or not.

4- Make Predictions

What predictions can you make based on observations that you made during the experiment?

Figure 7 Making predictions in the explore part of a sample experiment report

Record the Data: Students were asked to record the data obtained from the experiments and create tables by using these data in the data recording phase of the study. Both quantitative and qualitative data are obtained during an experiment. These data can be saved in many formats such as graphics, images and text files. Recording these data will help students to draw graphs in the next step. According to Temiz (2007), if the data is transferred correctly to the table, the analysis part would be easier. If the data is interpreted well, then it would be easy to get a good and consistent result.

5- Record the Data

Transfer the data you obtained to the table given below.

Table 1- Measurement Table

Table 2- Measurement Table

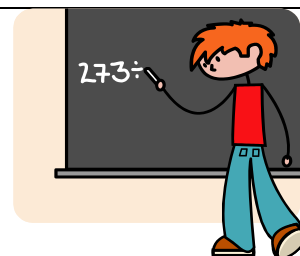


Figure 8 Recording the data in the explore part of a sample experiment report

2.4. Applications performed in the stage of explaining

Explaining phase of the experiment reports were divided into two sections. These sections are as follows:

Graph drawing: In this phase, students draw graphs according to data obtained from their experiments. They do share information about their graphs with their friends. In this way, students learn their findings, observations, designs and results of their experiments in an environment where they are encouraged to share and discuss with their friends. In addition, some space is left below each group for students to write their comments and thoughts about the graph.

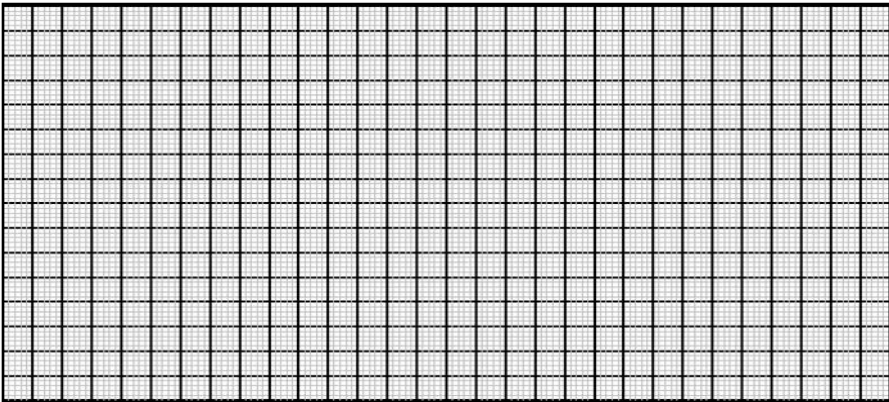
1- Drawing Graph	
Draw the proper graph or graphs by using the data you have obtained.	
	
(Graphic-1)	
Interpret the graph:	

Figure 9 Drawing graph in the explaining section of a sample experiment report

Inference: Inference is a judgment process by using the data obtained from experiments conducted. According to Harlan (1993), inference is a mental process that is used when data is collected. When this process is carried out systematically and carefully, some conclusions are reached by using a few pieces of information or observation with logical inferences. It is important to use the evidence collected while reaching a conclusion (Temiz 2007). Students were asked to write their predictions by using the experiment they conducted and graphs drawn.

2. Inference	
Which conclusions can be made based on the experiment and graphs that you have created.	
Result 1:	
Result 2:	
Result 3:	

Figure 10 Inference in the explain section of a sample experiment report

2.5. Applications performed in the stage of elaborating

In this stage, students were asked to give examples from their daily lives about the experiment. They apply new ideas and new opportunities obtained from these experiments by using their knowledge and experiences after deeply discussing with their friends on the upcoming events. The phase of sharing information is an important step since other students are included in this learning process, they re-think the accuracy of information and concepts they have learnt until that time and associate these concepts and information with concepts and information in other areas. Students apply the information they have obtained as a group on new events and situations in daily life.

D- TIME TO SHARE
Please write what you think about other applications that you see in your daily life after discussing with your group members.

Figure 11 Elaborating phase of a sample experiment report

2.6. Applications performed in the stage of evaluation

In the last stage, students make a conclusion by evaluating the information acquired. In the evaluation phase, students try to find answers for the questions asked in the light of the information and concepts they have learnt during the study. Approximately 3-4 questions were asked in each experiment and they were evaluated to see whether they have learnt or not. These conceptual questions were compiled from the literature and physics textbooks. In the evaluation of experiment reports, the measurement tool developed by Kanli (2007) according to 7E model was adapted to 5E learning model.

E- TIME TO EVALUATE WHAT WE LEARNT
Please answer the following questions based on the information and abilities obtained during this experiment.
Question 1: Tarzan is hanging on a tree and swinging to the other on a vine. At what point the vine is close to the breaking.
Question 2: Based on the experiment you have done, what can you say about the laws of pendulum?
Question 3: What do you think about the correctness of the following words? Please indicate the reasons if not correct.
a) Period (T) is inversely proportional to the square root of the gravity (g) at the point of oscillation. b) Period (T) is proportional to the square root of the length of pendulum (l). c) Period is not dependent of the substance and mass of the object. d) Period is not dependent on the oscillation amplitude for small angles $\alpha < 10^\circ$.

Figure 12 Evaluation phase of a sample experiment report 1

In the last part of the reports prepared, the mistakes made by the students during the experiments and reasons of these mistakes are presented.

What experiment mistakes we did during the experiment and what are the factors increasing the margin of error?

Figure 13 Evaluation phase of a sample experiment report 2

Conclusions and Recommendations

This study aims to develop materials to be used in physics laboratory in accordance with the 5E learning model. In the preparation phase of the 5E learning model, which is the first stage of the study, a fun and a remarkable entry was made, questions were asked to increase their curiosity, ensured that they have focused on the subject by using exciting events and we have tried to create questions such as "Why did this happen? How can I learn this subject?" to reveal students' prior knowledge and attract their attention while constructing their knowledge. In the second stage of the study called exploring, students were encouraged to think actively to solve the problems encountered and they were allowed to make observations, question and do research. In the third stage of the study called explaining, students were allowed to replace their incorrect or imperfect knowledge by new and correct information they gained during the experiment. We think conducting such activities, cooperating with students and making alternative explanations will help students to be successful in the laboratory classes.

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