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UNDERSTANDING THE EFFECTS OF THE SCIENCE MUSEUM OF PHYSICS SUBJECTS OF VOCATIONAL HIGH SCHOOLS STUDENTS

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Abstract
Physics lessons are known to be difficult for vocational high school learners because it requires abstract concepts and mathematical procedures. In this study, we investigate the effect of informal learning environment to understand magnetism and sound waves subjects on eleventh grade students. Two classes of eleventh grade students consisting of 12 and 13 individuals were selected. On the Expansion step of 4E learning models, the students visited the Izmir Karşıyaka Bahçeşehir College of Science Museum to comprehend the knowledge through daily lives. At the end of the practice, students' learning levels were evaluated by 20 multiple-choice achievement tests involving the magnetism and sound waves subjects and their attitudes to physics lessons. The behavior of the students in informal learning environments was observed during the field-trip. When academic achievement test results compared with the scores obtained from previous achievement tests, achievement test results increased and there was a significant increase in attitudes towards physics lessons. Direct observation showed that the students' learning requests were positive.

Key Words: 4E learning model, informal learning, vocational high school learners.

INTRODUCTION

Almost everybody thinks that all problems faced today are mainly related with education. Formal education institutions inevitably have responsibility in this context. Eliminating those problems in curricula for related disciplines we use in educational institutions is only one main objective. In that purpose , the goal of physics, chemistry, and biology curricula implemented in our schools is to help bring up individuals who research, inquire, scrutinize, make association between daily life and subject of science, who can use scientific method for solving problems faced in all areas of life, see the world from a scientist's perspective, and both understand and use appropriately nature of science and related principles, laws and theories (Çepni and Çil, 2009). As a result, it becomes a necessity to bring up "science literate" students in relevant fields of sciences and prepare students to upper level of physics, chemistry and biology education. Individuals who are capable of researching-inquiring, making effective decisions, solving problems, are self-confident, open to collaboration, are able to communicate effectively, and learn lifelong with the idea of sustainable development possess knowledge, skills, positive attitude, perception and values regarding sciences as well as understanding and psychomotor skills concerning the relationship of sciences with technology, society and environment. Students, in return, feel responsible for solving social problems and propose individual or collaborative alternative solutions by using their creative and analytic thinking skills.

Besides, science is not just a collection of facts about the world, but also experimental criteria, critical, creative, logical, reflective thinking and continuous query is based on a research and ways of thinking. As a consequence of such a way of thinking, individuals learn through direct access to the right information discovery, whether to revise the outlook on the world we learn to restructure and develop the growing enthusiasm for learning is very important. In our age when such behaviours and all other things rapidly change, especially due to daily increase of technological innovations, it has recently become more complex to interpret and learn life. There are not sufficient areas available for individuals' practising their knowledge acquired through education in real life in societies. In the world of science and technology, students cannot acquire knowledge and skills necessary for life with sciences knowledge taught in school. Furthermore, it can be argued that lack of opportunities to transfer knowledge learned at school to real life is the most important problem faced in science education. Leading cause of this problem is placing emphasis on purely theoretical knowledge without association with the real world. In fact, real problems and questions should lead the way for science education (Can, 2004, cited by Yılmaz and Huyugüzel Çavaş, 2006). Derived from such problems, the "constructive theory" allows development of thinking skills of students as it promotes discovery, research and direct experience with materials. It encourages learners to interact with each other for uncovering their knowledge (Brooks and Brooks, 1999). In this way, students gain experience regarding the concept they will learn. In order to put this theory into practice in formal education institutions, various instruction models like Learning Cycle, 4E, 5E and 7E come to the forefront. The literature provides abundance of studies revealing that they have a positive effect on students' learning at all ages.

In this study, the instruction model 4E was used in this study. It is called 4E due to four steps starting with "E" in English (**E**xplore, **E**xplain, **E**xpansion, and **E**valuation). The first E stands for the first step, which is ***exploring.*** This stage includes activities, experiments or expeditions comprising of collection and recording of data obtained by students using scientific processes such as observation, measurement, experiment, interpreting, prediction and setting a model in a learning environment organized by teacher. This step aims at enhancing students' learning departing from their own experiences. In this part of the model, the teacher provides instructions for an experiment, activity or expedition to be made without presenting theoretical information. Then, the teacher observes and listens to the students. The instructions and research questions provided at discovery stage are expected to encourage students to think and make comment. Its purpose is to get students to interact with their classmates, make predictions and hypothesize from the activities. This stage is followed by ***explaining***. Students analyse the data they discover at this stage. The answers and predictions they give departing from instructions and/or research questions are analysed individually or in groups and necessary corrections are made. Students are expected to explain and define concepts of science with their expressions, which is the crucial part. Unless they provide expected predictions or explanations, the teacher ask guiding questions so that they can achieve the aim. Once all students construct the concept and explain their interpretations, the teacher reveals and summarizes scientific meaning of the concept. The third E refers to the stage of ***expansion,*** in which teacher sets learning environments allowing application of the concepts in several places. The applications are used to help students expand their interpretations and apply it to their daily life. The concept can be applied to various situations such as doing additional experiments, reading various sources and books, solving relevant problems, computer applications, field studies, films, videos and demonstrations. The number of activities which can be done at that point is infinite. Lastly, in ***evaluation*** stage, students are expected to reveal their understanding or change their way of thinking or behaviours rather than traditional end-unit evaluation. Mostly, alternative evaluation methods should be used (Marek and Cavallo, 1997, cited by Yılmaz, Huyugüzel Çavaş, 2006; Özden 2008, cited by Demirci and Özmen, 2012; Türkmen, 2006; Türkmen and Usta, 2007).

The 4E instruction model was based on the mental development theory introduced by Piaget. Starting from the first step of exploring, a person is exposed to new stimulus and tries to give meaning in her/his mind. The person gets to the status of disequilibrium if s/he cannot establish a connection with prior knowledge. Since data collection is a factual process, the individual can get out of the disequilibrium on her/his own or with teacher's help. As s/he analyses the data by discussing with their peers at explanation stage, the individual switches to the accommodation stage. S/he comprehends scientific information at this stage. Afterwards, adaptation takes place during expansion stage by means of relevant examples and different problem statements. In this way, all new information becomes engaged in the individual's life by being linked with other information. (Kanlı, 2007; Türker ,2009; Türkmen, 2006).

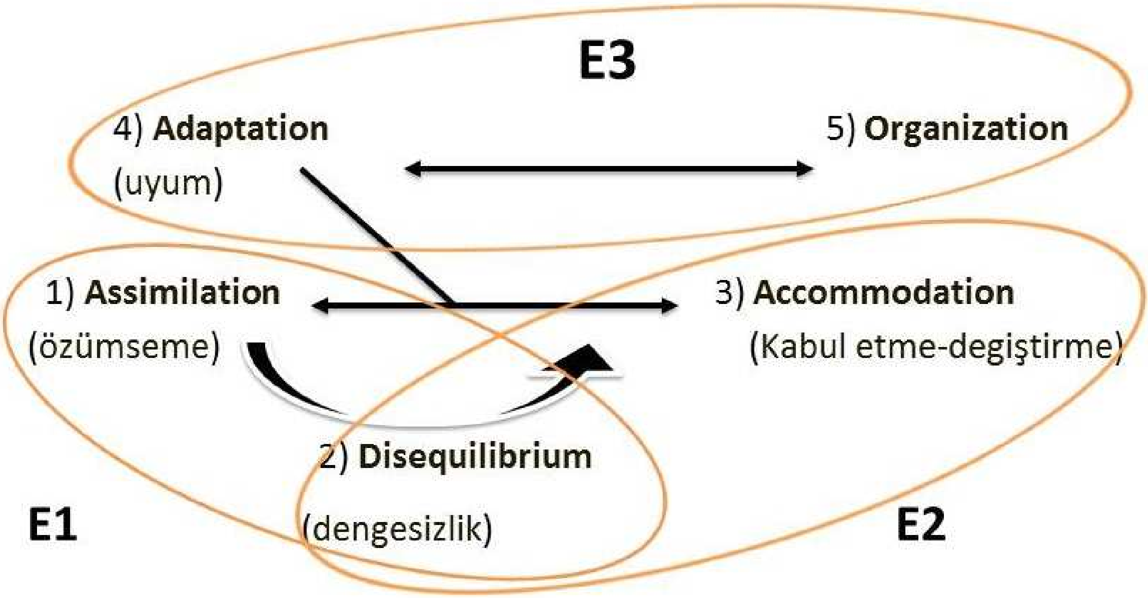

Figure 1: Mental development model with 4E teaching model

Informal learning environments where theoretical knowledge is linked to real life have considerable contribution to learning of individuals (Türkmen, 2010). Considering that science is about truths or possible truths in the nature, teachers must use the nature as learning environment. In environments such as school yards, universities, streets, shopping malls, home, offices, cultural and sports centres, science museums, aqua parks, forests, and natural parks, students' learning is supposed to differ from than in formal learning environments. The qualities informal learning environments must possess include following:

1. *Fun*: In informal environments, science must be taught with fun. The individual needs to enjoy the motivation to explore according to her/his areas of interest, and s/he needs to do it like playing a game, still in a disciplined manner. The informal environment must provide individuals the freedom of inquiring and exploring in relation with their interests and curiosity. The teacher should not expect silence or neatness in such a funny process.

2. *Voluntary basis*: For taking students to informal science environments, teachers have to take permission from school administration and parents (of students under 18). Teachers cannot take students from formal to informal environments without obeying such rules.

3. *Self-Directedness*: When teachers take their students to a science museum or botanic garden, they should allow students to decide on what to explore, see or do themselves. In this setting, the teacher is responsible for supporting students about how to learn, encouraging independent questioning and providing them with necessary materials and support.

4. H*ands-on learning:* It is an active learning mode. In this type of learning, individuals put their hands on the job so they can achieve knowledge through exploring instead of receiving direct explanation of the learning input from teacher followed by practices. It should be remembered that students need to use resulting experiences, emotions and ideas and scientific skills (questioning the data and whether or not such data are compliant with their scientific knowledge) and share their knowledge with other students.

5. *Open-endedness:* In informal science learning, there is no limited time concept. As exploring and questioning is essential for learner's access to knowledge, the learning process can be short or long as long as individual's interest is boosted.

6. *Non-Sequentiality:* Since learning takes place in individual's daily life, it can be independent on time and non-sequential. Also as individual undertakes observation, data collection, analysis and interpretation her/himself and attempts to explain science with her/his own daily life experiences, teachers can only play their roles at last stage by realizing whether or not they managed to reach conclusion. Therefore, it would not be sensible to expect problem solving skills to emerge in sequence.

7. *Purpose or deliberateness*: It should be kept in mind that schools or societies have a reason for being. Teachers need to identify a purpose for taking students to museum or botanic garden, build conditions for gaining of scientific knowledge in this opportunity, and lay the groundwork for such an experience. (Orion & Hofstein, 1994; Storksdieck, 2001; Tezcan Akmehmet & Ödekan, 2006, cited by Türkmen, 2010).

The aim of present study is to investigate the effect of informal learning environments during "expansion" stage of the 4E model on learning and attitude of students towards course. The study was carried out with students in the eleventh grade in a vocational high school in science museums. Study subject was about physics, in particular learning of magnetism and sound waves.

METHOD

Quantitative and quantitative research methods (mix method) were used in this study. Study data were analysed with "One-Group Post-test Only Design".

Population and Sample

Convenience sampling was used in this study. The study was carried out in İzmir. 25 students attending the 11th grade in Anatolian Technical and Industrial Vocational High School participated in this study.

Data Collection Instrument

In the study, quantitative data collection tools such as achievement test and Likert type scale on attitude regarding physics. The achievement test consists of 20 multiple choice questions covering magnetism and sound waves. The other instrument, physics attitude scale, was developed by Nalçacı, Akarsu and Kariper. It is comprised of 30 items in Likert type, and its reliability coefficient was found to be 0,940. Moreover, a qualitative data collection method was used in this study. Direct observation was done in order to find criteria and students' behaviours necessary for the science museum to be an ideal learning environment.

Data Collection Process

In physics course in the 11th grade, the unit on Magnetism and Waves was taught by means of activities formed in compliance with 4E learning model. Expansion stage was carried out with activities in science museum as an informal learning environment.

In *exploration,* the first step of the class, the students were seated and stayed in groups till the end of teaching of the topic. Each group was given magnets with differing size and force. Then, they used the batteries, copper wires, clips, iron sand, ruler, plastic, and nails provided before to see attracts or repels status of magnets. They could understand that magnets have opposite poles upon seeing that one end of magnets attracts a magnet while the other end repels it by changing direction of the magnets. Next, the students put some iron sand around the magnet to realize the magnetic field. The batteries were used for setting an electrical circuit. A ring-shaped coil was made by using a piece of copper wire. While current flowed through the circuit, a magnet was put near the coil and it was seen that the ring started moving. After that, the circuit was repeated by using batteries, conducting wire and a nail surrounded with wire. When current flowed through the circuit, the nail attracted iron sand. In this way, the students observed that effects of magnetic items like magnets are formed around a piece of wire in which current flows. In other words, current has a magnetic effect.

Following the activities (picture 1), the students at *explanation* stage proposed ideas regarding results they obtained from the activities. They tried to explain what factors are influential on magnetic force and pointed that a piece of wire with current reacts like magnet. They compared comments made according to the formula of magnetic force. They defined the relation of a wire having current with magnetic field and compared the

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explanations made with the formula of magnetic field formed around the conducting wire. In following lesson, the participants were taken to İzmir Bahçeşehir Science Museum to help students interpret what they have learned and transfer it to their immediate life. The course teacher visited the museum before the study to find out whether or not the stations found as well as activities realized are related with magnetism and sound waves learnt by students. After obtaining necessary permissions from parents and school administration, an appointment was made with the science museum. They did experiments at stations in the museum. As a result, they could apply both previous learning and topics covered in units to real life. The participants visited the stations in predetermined groups. At that stage, answers were sought for the research questions developed by the teacher by using the criteria needed for using the science museum as a learning environment. After the excursion, achievement test was given to find out students' level of learning at school. Also an attitude scale was administered to find out their feelings and opinions regarding the learning experience.

Picture 1: Students' experiences at the stage of exploration

FINDINGS

For expansion, the teacher's observation noted during application of the learning environment criteria in the science museum are given in Table 1.

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Table1: Observed data

Criteria for informal learning environment	Observation
1. Fun:	All of the students had fun in that environment according to my observation and students' feedback. (100%)
2. Voluntary basis:	24 students (96%) attended the excursion voluntarily. 1 student (4%) could not attend due to private reasons.
3. Self-Directedness:	The students obeyed measures and rules necessary for attending all stations and doing observation (100%).
4. Hands-on learning:	The students took an active part in 6-7 of the experiments (100%).
5. Open-endedness:	Critical questions were asked to students without letting them know what happens at the stations.
6. Non-Sequentially:	Experiments were held at stations regardless of connection or sequentially.
7. Purpose or deliberateness:	The excursion was linked with the topic of magnetism and sound taught during the course in school.

Average achievement test score was calculated to be 53 at evaluation stage of the 4E. Considering the fact that average score of the students was 41,5 at the first physics midterm during the second semester, the increase becomes obvious. Particularly, the students who got low scores from the first examination improved. As a result of the physics attitude scale of Nalçacı, Akarsu, Kariper (2011), minimum and maximum scores were noted as 66 and 140, respectively (minimum score was 30 and maximum score was 150).


Picture 2: Students joined the experiment in science museum)

Total average of the participants was calculated to be 3.52. It could suggest that students at vocational high school could develop positive attitude towards physics though it was regarded as an unnecessary but compulsory work. In addition, the students were inspired by the stations and experiment systems on the field visit. Thus, they made up a "physics corner" with mechanisms they themselves set up in physics course. Then, they were exhibited in the school. Those activities were explained and exhibited by the student who made up the mechanism.

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Picture3: Corner of physics fair

In physics course, the participants were asked to make a special corner to exhibit physical experiments or interesting activities they had seen at the stations in the museum. Then, they practised those experiments in classroom so that all other students could see.

DISCUSSION AND CONCLUSION

4E teaching model is student-centred, and our study was implemented at expansion stage. In this scope, an excursion was held in science museum. The using expansion level of 4E teaching model in informal learning environment on physics education has positive effect on students' learnings. During implementation of the study, the participants were experienced hands-on learning. As a consequence of that, retention of physics knowledge increased and thus the students developed their skills of solving problems in their daily lives. According to our observation during the excursion, it could be suggested that the students had difficulty in understanding basic physics mainly due to incompetence in mathematical operations rather than lack of knowledge in physics. Also it was observed during the excursion that interest and participation level was high at experiment stations and they played an active role in the study by means of questions asked occasionally. Though physics is considered unnecessary by most vocational high school students, we are of the opinion that physics has connections with all areas of life. Therefore, it can be argued that students will be more eager to learn physics once it is supported with out-of-class activities during such an excursion and students realize physics in practical areas. There are other studies pointing out that using of an effective informal learning environment affects learners positively (Anderson, Lucas, & Ginns, 2003; Ash, 2003; Falk and Dierking, 1997; Griffin, 2004; Wolins, Jensen, and Ulzheimer, 1992). Such positive effect can best be understood from long-term impact. Falk and Dierking (1997) found out that elementary students could keep memories of the excursion in their mind for a long time and they could remember what they learnt in that place even years later. In present study, the students from vocational high school reported that they still remembered their experiences and information related with the excursion after days. They also expressed their eagerness to go on similar visits for other topics.

RECOMMENDATIONS

We think that importance should be placed on this subject and students should be encouraged to learn in informal learning environments. To this end, also as suggested by Türkmen (2010), we academicians can urge YÖK (The Higher Education Council) to insert relevant courses in curriculum so as to train preservice teachers accordingly. Furthermore, joint projects can be implemented by MEB (Ministry of National Education) and universities to give in-service training for teachers currently teaching at schools. Last but not the least, informal instruction environments should be made more common especially in sciences such as well-equipped science museum, science centres, natural areas (parks) or special areas such as botanic gardens, observatories, aqua parks. For this, Ministry of National Education as well as other ministries can take the initiative to increase the number of such places.

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