Effectiveness of technological design on elementary student teachers' understanding of air resistance, gravity, terminal velocity and acceleration: Model parachute race activity

Miraç AYDIN[1], Hasan BAKIRCI[2], Hüseyin ARTUN[3] and Salih ÇEPNİ[4]

[1,2,3] Karadeniz Technical University, Fatih Faculty of Education, Department of Primary Science Education, Trabzon, TURKEY

[4] Uludag University, Faculty of Education, Department of Primary Science Education, Bursa, TURKEY

E-mail: miracaydin81@gmail.com

Received 11 Jun., 2012
Revised 24 Jun., 2013

Contents

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Abstract

Educational research maintains that, teaching science through designing technology has significant educational potential. Although the literature emphasizes that making technological designs is beneficial for students, it is stressed that studies about technological design generally focus on mental structures rather than hand skills of students and learning by doing and experience. In this study, we tried to determine the effect of a "Model Parachute Race" activity on elementary student teachers' levels of understanding of concepts such as air resistance, gravity, terminal velocity and acceleration using a qualitative methodology. In this context, elementary student teachers' levels of understanding of concepts were determined before and after the activity, and change was revealed through analyzing the difference between them. It was found that elementary student teachers learnt science concepts better during technological design process than during traditional science lessons. In addition, it is thought that if a technological design process is supported with theoretical information, desired change will occur in levels of understanding the science concepts.

Keywords: Technological Design, Elementary Student Teachers, Parachute Race Activity, Air Resistance, Gravity, Terminal Velocity, Acceleration

Introduction

Educational researchers maintain that, teaching science through designing technology has significant educational potential. Pupils could be more familiar with and discuss scientific concepts, when they are engaged in designing and building technological artifacts (Roth, 2001; Sidawi, 2009). In addition, students can convert abstract concepts involved in their design into concrete concepts in their mind (ITEA, 2003, 2007). In this study we focus on the effects of designing technology activities while learning some specific concepts such as Air Resistance, Gravity, Terminal Velocity and Acceleration related to building a model parachute.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Theoretical Framework

The literature was reviewed in order to examine studies concerning the effects of the process of undertaking technological design in understanding science concepts. According to, a study by Roth (2001) aimed for elementary school 6th and 7th grade students to make technological designs by using various tools and accordingly to learn certain science concepts. To this end, an experimental environment was designed in order for students to lift a heavy object easily. In this study, students were assessed through interviews conducted in 3 stages: before the unit, during the unit, and after the unit. At the end of the assessments, it was concluded that technological design activities enabled students to learn science concepts such as force, energy and simple machines more easily and much better than by traditional methods.

Wu & Hsieh (2006) conducted a study to determine how 58 sixth grade students developed their research skills in a research-based learning environment. In the study, students were required to design an electric motor and factors influencing rotating speed of the motor were determined. In this study, a research skill test was used. This test was administered as pre-test and post-test in order to evaluate research skills of students. At the end of the designing activities, it was concluded that research-based activities improved research skills of students to a large extent.

A study carried out by William et al. (2007) investigated the effect of a "Summer Robotic Camp" in which 21 sixth grade students engaged in science concepts and the scientific research skills that had developed as a result of the camp. During the "Summer Robotics Camp", students were required to create designs about science concepts such as Kinetic Energy, Gravity, Speed and Weight. In this study, a research skill test was employed. This test was administered as pre-test and post-test to evaluate research skills of students. The obtained results indicated that knowledge of students about science concepts had developed, but their scientific research skills did not improve.

Mettas & Constantinou (2007) included 82 prospective teachers in their study investigating whether a technology fair influenced the interests of prospective teachers in technology and whether this process affected problem solving skills of prospective teachers, and revealed problem solving strategies of students. 82

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

prospective teachers received a 4-week training program in technological design within the scope of a course at the faculty where they were prospective teachers, and then these prospective teachers were asked to create a technological design. Later, each one of these prospective teachers was sent to an elementary school and elementary school students were asked to create technological designs under the guidance of these prospective teachers. The obtained products were introduced to visitors in an exhibition named Technology Fair. In this study, a technological design evaluation test, interview and reflective journals were used for assessing products obtained at the end of the technological design activities. It was concluded that at the end of this study the application improved technological problem solving skills and motivations of prospective teachers. In addition, all prospective teachers performed the application willingly. It was concluded that this application would introduce an important experience to them for their teaching experiences in the future.

Frazier & Sterling (2008) aimed to teach science concepts to elementary school students by making a “model car” design. Students, working in groups, designed a model car by using tools such as cable, motor and battery. It was realized at the end of the study that students learnt abstract science concepts (concepts such as circuit, current, voltage) better through a technological design process. Nugent et al. (2010) investigated the impact of “robotic and geospatial” techniques on science, technology, engineering and mathematics attitudes and concepts in the study which they carried out with 147 elementary school students. In this study, students were evaluated by means of a 33-question likert type surveys. Students studied at a “Summer Camp”. At the end of this camp, it was understood that the attitudes of students towards Science, Technology, Engineering and Mathematics lessons and their conception of these areas were improved.

Barak & Zadok (2009) investigated the learning and problem solving abilities of a group of 7th and 8th grade elementary school students. In the Barak & Zadok (2009) study, students developed a wide range of tools from fishing line to remote operating vehicle by using toy blocks in courses containing content-weighted lessons in the first year, project-based lessons in the second year, and project-based and content-supported lessons in the third year. For assessment of students; journals, conversations, photos of developed tools, video recordings of some lessons, records of discussions with students and their parents were used. Data were presented through a descriptive analysis. According to results obtained, students succeeded in developing solutions to technological problems. However, they encountered various

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

difficulties during this process. Within designing process, students generally used "Qualitative Knowledge" which required the skill of explaining particular events without using physics formulas or mathematical operations. In addition, this study revealed that students collected more information through informal ways rather than formal ways during the designing process. Barak & Zadok (2009) recommended investigation of how teaching methods applied for these concepts would affect understanding levels of students about these concepts.

Bencze (2010) conducted a study that providing 78 prospective teachers with an experience to carry out technological design projects and scientific studies. In this study, case study, anecdote records, student practices, semi-structured interviews and surveys were employed. Within the scope of the study, prospective teachers were asked to create a technological design for a long course period. At the end of the study, it was determined that self-confidences of prospective teachers increased while creating technological designs. In addition, it was realized that technological designs created in Science and Technology lessons improved learning levels of prospective teachers in terms of concepts about this topic.

Hakkarainen, Viileo & Hakkarainen (2010) conducted a study that involved showing 4th and 5th grade students how to use a liquid crystal display (LCD) model in an application, how to provide technological support within a technological design process, and how to shape learning environment around a forum site and designs associated with concepts. This longitudinal study took a total of 13 months (3 semesters). A teacher and a researcher were made to prepare a forum site and databases, journals, and create technological designs about some science concepts for 13 months. Designs created in the study included Motion, Light, Force, Power, Operating Mechanics of Clock and Magnetism. It was concluded at the end of the study that activities carried out during the technological design process contributed rich experiences to the learning environment and improved cooperation between students. In addition, it was seen that teacher took part as a guide in contributing to cooperation rather than controlling the learning environment.

Moore, Chessin & Theobald (2010) examined the way pre-school students developed a tool that allowed them to examine insects without harming them. That is to say, they aimed for students to be able to make a distinction between a spider and an insect and design a tool allowing for examining these living beings without harming them. In this study, teacher's observation reports were used. Students

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

worked in groups. According to observation reports of teachers, students succeeded in making a distinction between a spider and an insect thanks to these tools they developed. According to results obtained from these studies, abstract science concepts appear in every stage of education from primary school to high school and university. It is understood that technological designs are made for students to concretize abstract science concepts they encounter, and these designs enable science concepts to be learnt better and scientific research skills of students to develop. These studies emphasize the necessity of creating technological designs in order for science concepts to be learnt better. Although the literature emphasizes that creating technological designs is beneficial for students, it is stressed one the one hand, that studies about technological design generally focus on mental structures rather than the hand skills of students and learning by doing and experience (Roth, 2001; Mioduser & Dagan, 2007; Barker et al., 1998; Oliver & Hannafin, 2001). On the other hand, it is stressed that there is a limited number of studies concerning students' understanding of related concepts while making technological designs (Barak & Zadok, 2009; Silk et al., 2010). Accordingly, this study was carried out for prospective classroom teachers to concretize abstract concepts of science lesson and to ensure permanent learning through technological design.

Research Questions

The present study attempted to determine change in elementary student teachers' levels of understanding of the concepts of Air Resistance, Terminal Velocity, Gravity and Acceleration as a function of engagement in a "Model Parachute Race" activity.

In this study, we examined the research question below:

What effect did the "Model Parachute Race" activity have on elementary student teachers' levels of understanding of concepts such as Air Resistance, Gravity, Terminal Velocity and Acceleration?

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Methodology

In this study, we tried to determine the effect of a "Model Parachute Race" activity on elementary student teachers' levels of understanding of concepts such as air resistance, gravity, terminal velocity and acceleration through a qualitative methodology. In this context, elementary student teachers' levels of understanding concepts were determined before and after the activity and change were revealed through analyzing the difference between them.

Objective of "Model Parachute Race" Activity

The "Model Parachute Race" activity aimed for elementary student teachers to develop a model and a parachute that could remain in the air for a long time by using technological design stages and concepts such as Air Resistance, Gravity, Terminal Velocity and Acceleration. In this scope, it was aimed at contributing to elementary student teachers' understanding of technological design stages, enabling elementary student teachers to understand concepts of Air Resistance, Gravity, Terminal Velocity and Acceleration that have an impact on remaining of parachute in the air, and enabling elementary student teachers to gain an experience in the process of making a technological design.

Participants of "Model Parachute Race" Activity

Participants of this study were 39 second grade elementary student teachers studying at Fatih Faculty of Education Department of Primary Education Classroom Teaching in Karadeniz Technical University, Turkey. This study was carried out for 12 weeks within the scope of the lesson of Science and Technology –Laboratory Practice-II during the 2009–2010 spring semesters. The teachers making up the sample were divided into 7 groups, and each group elected their own group representative.

Steps Followed in Instructions of "Model Parachute Race" Activity

The 1st week

Elementary student teachers are divided into 7 groups each of which consists of 5-6 students, and one speaker is elected for each group,
Objective, rules and assessment criteria of "Model Parachute Race" activity are

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

distributed to elementary student teachers,
Technological design stages are expressed,
A website was prepared for establishing an effective communication with students also outside the lessons (www.fenegitimi.com/parasut) is introduced.

The 2nd week-The 11th week

Elementary student teachers develop their model parachutes through technological design stages,

The 12th week

The report introducing the developed model parachutes is written and presented, and model parachutes are raced.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

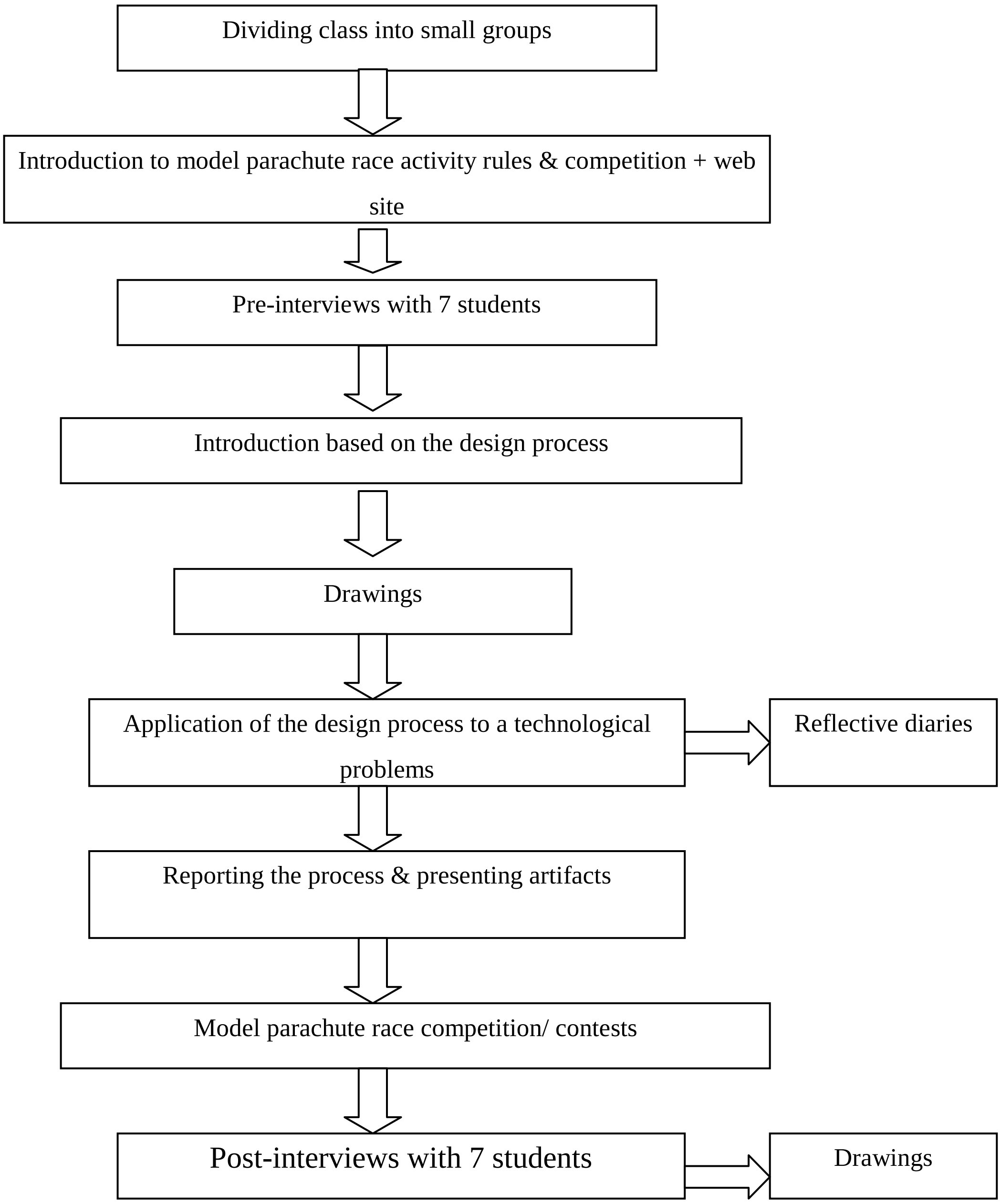


Fig. l: Steps followed in the research process

Data Collection

White & Gunstone (1992) pointed out that various methods could be used for measuring levels of understanding of concepts. In this study: concept maps (Safayeni, Derbentseva & Canas, 2005; Chiou, 2008; Liu & Wang, 2010; Hay, Kinchin & Baker, 2008); interviews related to concepts (Bjerg & Rasmussen, 2008; Kinchin, Streatfield & Hay, 2010); and drawings (Tsaparlis & Papaphotis, 2009; Trigueros & Planell, 2010; Howards-Jonesa, Winfield & Crimmins, 2008) were used in order to reveal the effect of the "Model Parachute Race" activity on elementary student teachers' understanding of science concepts. These data collection tools were applied to representatives of seven groups constituting a sample of the application, before and after the application. Opinions of two instructors in two different fields and two experts were taken while preparing semi-structured interview questions related to the concepts.

Interviews and journals were used for each group during the twelve-week activity in order to investigate the effect of "Model Parachute Race" activity in elementary student teachers' levels of transferring the concepts of Air Resistance, Gravity, Terminal Velocity and Acceleration into application.

Data Analysis

In this study, qualitative data obtained through semi-structure interview, drawing, concept maps and student journals were analyzed by means of NVivo 8.0 package. In accordance with this purpose, the obtained data were encoded and themes were constituted (Miles & Huberman, 1994; Yıldırım & Şimşek, 2005; Çepni, 2010).

In analysis of data related to the research problem; semi-structured interview, drawings and concept maps were used in order to reveal changes in levels of understanding of concepts. Data obtained before and after application were encoded by three researchers. Compliance of encodings performed by three researchers was examined in order to ensure reliability. Cohen's Kappa coefficient of obtained data was found as 0.72. These codes on which researchers reached a consensus constituted understanding levels concerning each concept. Accordingly, three codes (understanding levels) were detected for Air Resistance, Gravity, Terminal Velocity and Acceleration. Levels were given in an ascending order. Constituted levels were encoded as Level 1, Level 2, and Level 3 and symbolized as L1, L2 and L3. Levels are showed in Table 1.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Results

Table 1 showing levels of understanding of concepts of Air Resistance, Gravity, Terminal Velocity and Acceleration according to data analysis is presented below.

Table 1. Codes (understanding levels) for the concepts of Air Resistance, Gravity, Terminal Velocity and Acceleration

Concepts	Levels	
Air Resistance	Level 1	Incomplete definition of air resistance, and giving misinformation
	Level 2	Explaining the concept of air resistance at knowledge level
	Level 3	Making scientific definition of the concept of air resistance, associating the concept with daily life, and giving examples from one's environment about the concept
Gravity	Level 1	Incomplete definition of the concept of gravity at knowledge level, and misinformation about the concept
	Level 2	Defining the concept of gravity at comprehension level, and explaining it with different concepts,
	Level 3	Making scientific definition of the concept of gravity and giving examples about the concept
Terminal Velocity	Level 1	Failure in defining the concept of terminal velocity, or giving misinformation
	Level 2	Defining the concept of terminal velocity at knowledge level, and explaining the concept through association with other concepts one knows
	Level 3	Defining the concept of terminal velocity, giving simple examples or associating the concept with daily life
Acceleration	Level 1	Now knowing the concept of accelerated motion or giving misinformation
	Level 2	Defining the concept of accelerated motion at knowledge level, expressing it through association with other concepts one knows
	Level 3	Defining the concept of accelerated motion and supporting it with examples from phenomena and events in one's environment

The Effect of "Model Parachute Race" Activity on Change in Elementary Student Teachers' Levels of Understanding the Concept of Air Resistance

The change in groups' levels of understanding the concept of Air Resistance formed based on data obtained before and after the application is presented in Figure 2.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

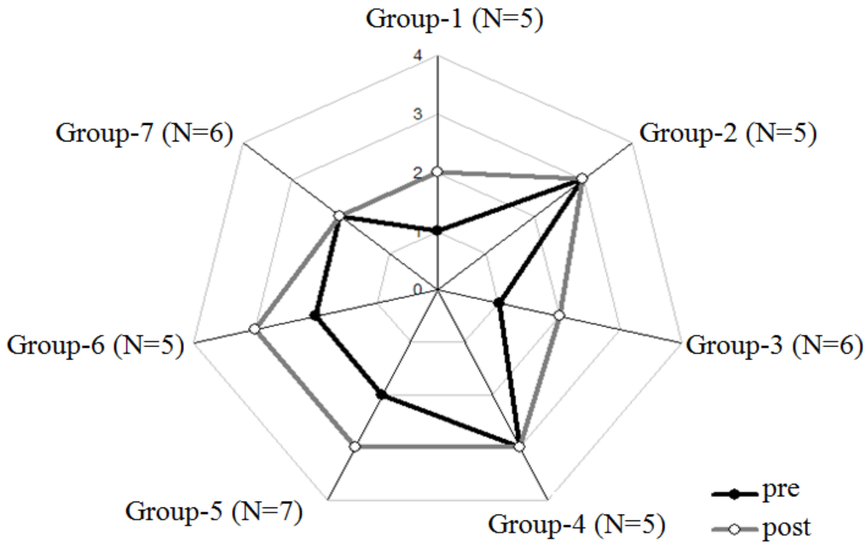
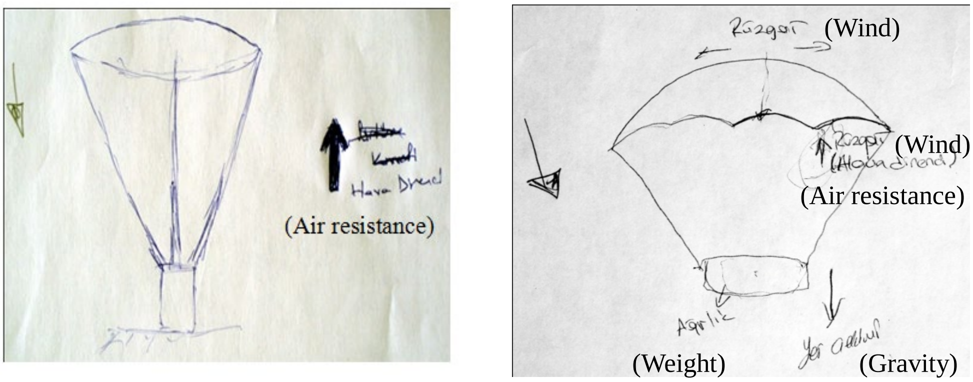


Fig. 2: The Change in Elementary Student Teachers' Levels of Understanding the Concept of Air Resistance

While examining Figure 2, it could be seen that levels of understanding of Group 2 and Group 4 did not vary before and after application (L3). It is understood that Group 7's levels of understanding the concept of Air Resistance did not vary before and after the application (L2). While understanding levels of Group 1 and Group 3 were Level 1 before application, their levels rose to Level (L2) after the application. It was seen that understanding levels of Group 5 and Group 6 rose to Level 3 (L3) from Level 2 (L2). Within this context, in the interview conducted with elementary student teachers' representing Group 5 before the application, Air Resistance was defined as, "*The force applied to an m mass object while it is descending from a particular height.*" (L2: Expressing the concept of air resistance at knowledge level). It was seen that, after the application, the concept was defined as, "*Air resistance can be defined as a force making a reverse direction effect on motion of an object; for example considering the parachute we made, I can say that the force preventing descending from a particular height is air resistance*" (L3: Making scientific definition of the concept of air resistance, associating it with daily life and giving examples from one's own environment). Drawings of Group 5 related to the concept of Air Resistance before and after the application are given in Figure 3.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.



Before the Application After the Application

Fig. 3: Sample Drawing Related to the Concept of Air Resistance Before and After the Application

The Effect of "Model Parachute Race" on Change in Elementary Student Teachers' Levels of Understanding the Concept of Gravity

The change in groups' level of understanding the concept of Gravity became evident based on data obtained before and after the application is presented in Figure 4.

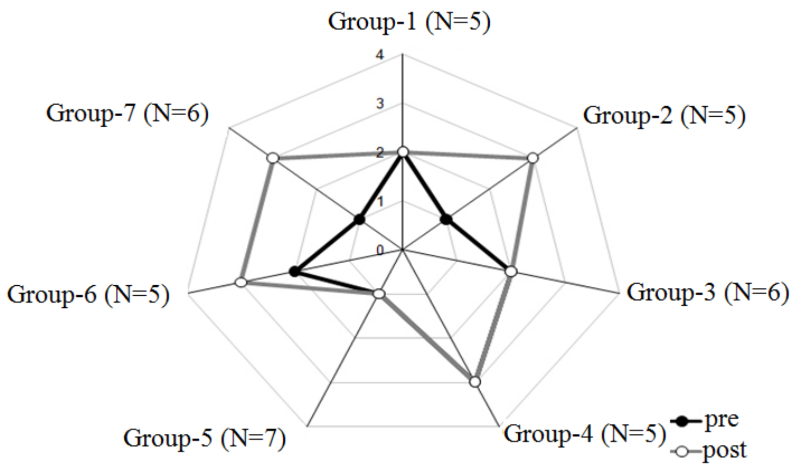
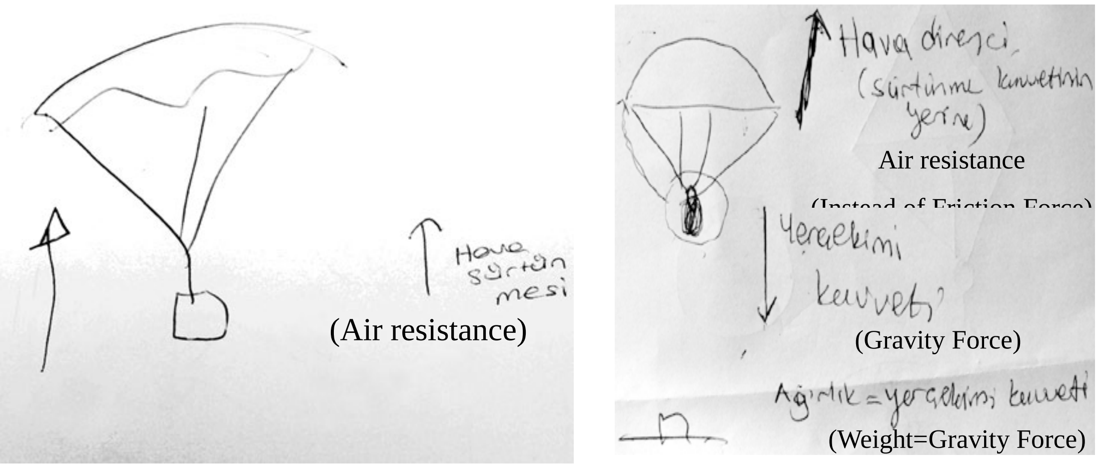


Fig. 4: The Change in Elementary Student Teachers' Levels of Understanding the Concept of Gravity

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

While examining Figure 4, it will be seen that levels of Groups 1, 3, 4 and 5 did not vary before and after application, and their levels are respectively L2, L2, L3 and L1. It was seen that while levels of Groups 2 and 7 were Level 1 (L1) before the application, they rose to Level 3 (L3) after the application. While level of Group 6 was Level 2 (L2) before the application, it rose to Level 3 (L3) after application. In this context, it was seen that, in the interview conducted with elementary student teachers' representing Group 7 before the application, the concept of Gravity was defined as, "*The place covered by object or the place covered by mass in the space.*" (L1: Incomplete definition of the concept of gravity at knowledge level, and misinformation), while the concept was defined as, "*Gravity is the gravitational force affecting the object. For example, if the object attached to parachute is heavier, parachute falls more rapidly.*" after the application. (L3: Making scientific definition of the concept of gravity, and giving examples). Drawings of Group 7 related to the concept of gravity before and after application are given in Figure 5.



Before the Application After the Application

Fig. 5: Sample Drawing Related to the Concept of Gravity Before and After the Application

The Effect of "Model Parachute Race" Activity on Change in Elementary Student Teachers' Levels of Understanding the Concept of Terminal Velocity

The change in groups' level of understanding the concept of Terminal Velocity formed based on data obtained before and after the application is presented in Figure 6.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

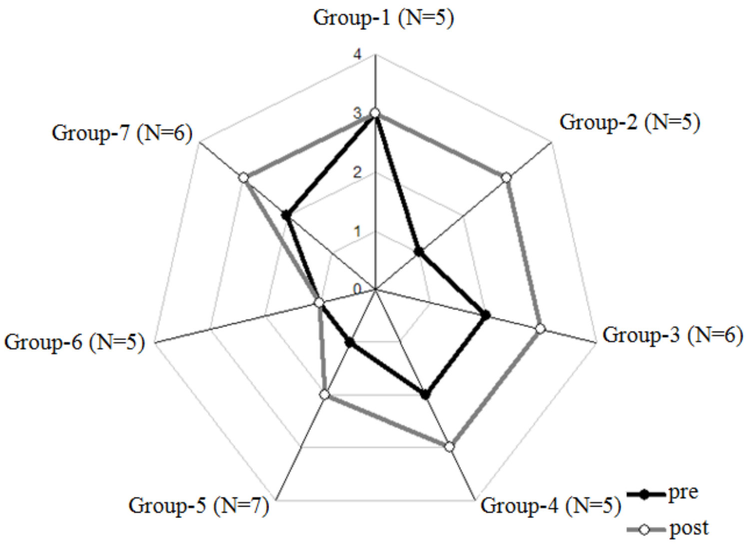
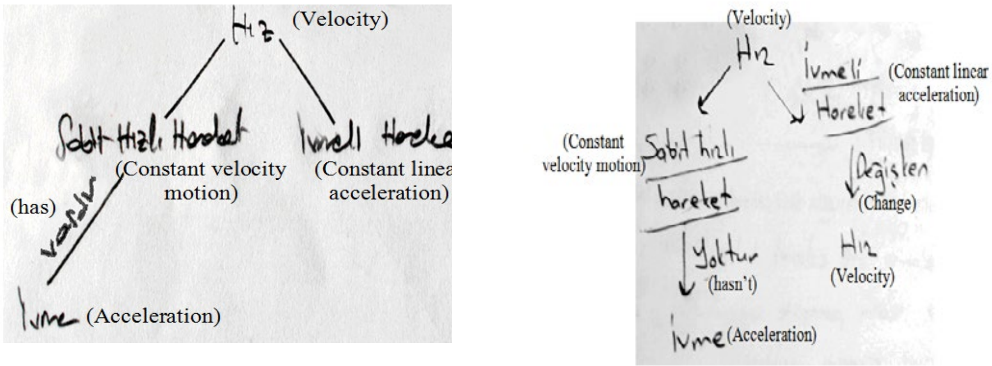


Fig. 6: The Change in Elementary Student Teachers' Levels of Understanding the Concept of Terminal Velocity

Upon examining Figure 6, it is seen that levels of Group 1 and Group 6 did not vary before application and after application; they are respectively L3 and L1. It was seen that while the level of Group 5 was Level 1 (L1) before the application, it rose to Level 2 (L2) after the application. It was understood that while levels of Groups 3, 4 and 7 were Level 2 (L2) before the application, their levels rose to Level 3 (L3) after the application. It was determined that while the level of Group 2 was Level 1 (L1) before the application, it became Level 3 (L3) after application. In this context, while the concept of Terminal Velocity was defined as, "*If an object has a terminal velocity, it has acceleration, but it is a constant value*" in the interview conducted with elementary student teachers' representing Group 2 before the application (L1: Failing to define the concept of terminal velocity motion or giving misinformation), it was defined as,"*It is the speed of an object not changing in the course of time. For instance, the parachute we made has firstly an accelerated motion and then a terminal velocity motion.*" after the application. (L3: Defining the concept of terminal velocity, giving simple examples or associating the concept with daily life). Concept map of Group 2 related to the concept of Terminal Velocity before and after application is given in Figure 7.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.



Before the Application After the Application

Fig. 7: Sample Drawing Related to the Concept of Terminal Velocity Before and After the Application

The Effect of "Model Parachute Race" Activity on Change in Elementary Student Teachers' Levels of Understanding the Concept of Acceleration

The change in groups' level of understanding the concept of Acceleration formed based on data obtained before and after the application is presented in Figure 8.

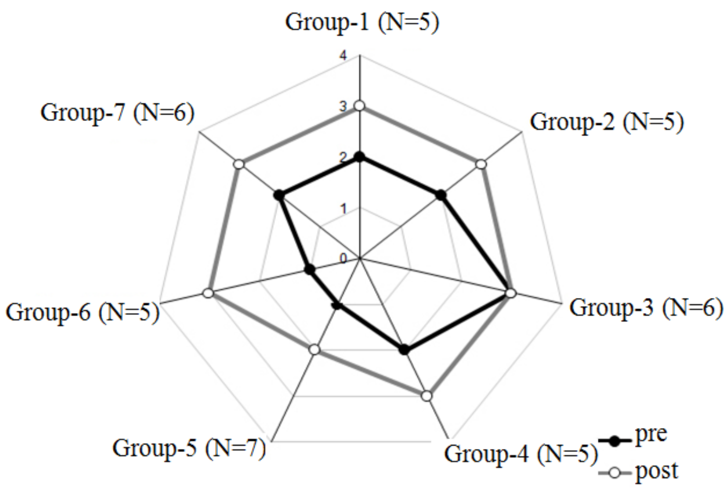
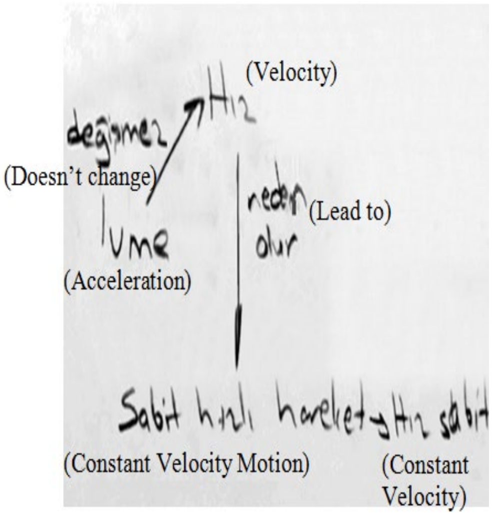


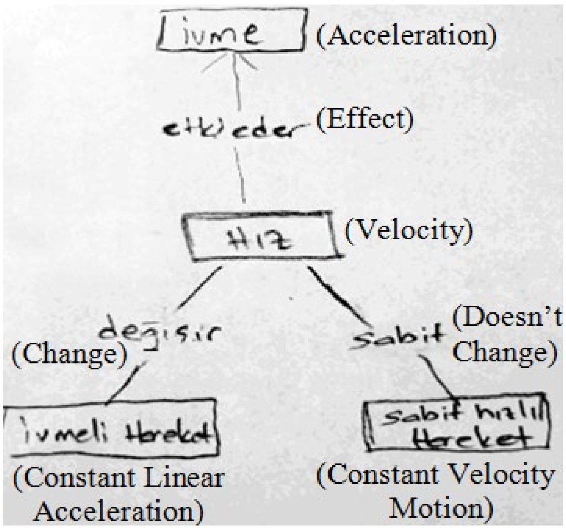
Fig. 8: The Change in Elementary Student Teachers' Levels of Understanding the Concept of Acceleration

While examining Figure 8, it will be seen that the level of Group 3 did not vary before and after the application, that is to say, it was Level 3 (L3). It was seen that

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

while the level of Group 5 was Level 1 (L1) before the application, it rose to Level 2 (L2) after the application. It was realized that while the level of Group 6 was Level 1 before the application, it rose to Level 3 (L3) after the application. While levels of Groups 1, 2, 4 and 7 were Level 2 before the application, they rose to Level 3 after the application. In this context, it was seen that in the interview conducted with prospective teacher representing Group 6 before the application, prospective teacher defined the concept of Acceleration as; "*It is the concept not varying according to speed of the object*" (L1: Not knowing the concept of accelerated motion and giving misinformation), prospective teacher stated, "*It is the change occurring in speed of an object in a unit of time. For instance, I can say that when our parachute is released, it has an accelerated motion after a particular period of time due to the change occurring in its speed*" after the application (L3: Defining the concept of accelerated motion, and supporting it with examples from phenomena and events in one's environment). The concept map of Group 6 related to the concept of acceleration before and after application is given in Figure 9.





Before the Application After the Application

Fig. 9: Sample Drawing Related to the Concept of Acceleration Before and After the Application

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Discussion and Conclusion

It was seen that there was an increased in elementary student teachers' levels of understanding the concepts of Air Resistance (See. Figure 2), Terminal Velocity (See. Figure 6) and Acceleration (See. Figure 8). This result shows agreement with the result of the study by Roth (2001) related to student learning while creating technological designs. According to Roth (2001), creating technological designs contributes to students' learning of science concepts in various ways. A similar result is seen in the review study carried out by Sidawi (2009) aimed at achieving science teaching through technological design activities. Creating technological design in science teaching contributes to the development of conceptual knowledge of students as well as their procedural knowledge.

The change occurring in elementary student teachers' levels of understanding of the concept of acceleration is indicated in Figure 8. The number of groups displaying improvement in understanding related to the concept of acceleration is higher than the number of groups displaying improvement in understanding related to concepts of Air Resistance and Terminal Velocity. This shows that prospective teachers included in the sample learnt the concept of acceleration better than other concepts in the process of "Model Parachute" and "Model Parachute Race". It is thought that there are 2 factors behind this result. The first one is about works performed in the designing process, and the second one is about trial flights performed in order to test endurance of prepared model parachutes. It is seen that, in drawings and interview conducted with elementary student teachers' representing Group 6 before the application (see. Figure 9), the elementary student teachers' defined the concept of Acceleration incorrectly. The same elementary student teachers' defined the concept of Acceleration correctly in the interviews conducted after the application. It can be said that correct definition of the concept of Acceleration by elementary student teachers' comes from research activities performed with group mates. It can be concluded that Group 6 reached the correct definition while applying the concept of Acceleration in the "Model Parachute" design. Since elementary student teachers' cannot directly observe Acceleration only during trials performed with group mates in the designing process without doing research about the concept of Acceleration, they cannot reach the concept of Acceleration correctly. The change occurring in the concept of Acceleration can be reached only through research about the concept and transfer of obtained information into design. It was reported in a study conducted by

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Brandt (1998) that a technological design process enabled students to transfer theoretical information they obtained into application. Barak & Zadok (2009) concluded that students were responsible for their own learning within the process of technological design, and they had to do research apart from simple trial-and-error activities while creating a design in order to put forward a successful product. It was stated that doing research about the topic contributed to concretization of abstract concepts (Roth, 2001; ITEA, 2003, 2007).

Upon examining the chart of change in understanding level related to the concept of Gravity (see. Figure 4), it will be seen that, unlike changes in understanding levels related to Air Resistance (See. Figure 2), Terminal Velocity (See. Figure 6) and Acceleration (See. Figure 8), the number of groups displaying a development in understanding level related to the concept of gravity was less than the number of groups showing no development in the understanding level. This result may be interpreted in a corollary that elementary student teachers’ did not achieve an adequate learning of the concept of Gravity. It is seen that elementary student teachers’ did research about concepts such as Air Resistance, Terminal Velocity and Acceleration within the process of designing a "Model Parachute", but did not do any research about the concept of gravity. It was seen that elementary student teachers’ performed direct trials in order to see the impact of gravity on endurance of parachute without doing any research. Although these trials contributes to the use of the most appropriate gravity in the designs elementary student teachers’ made, this caused them to fail to produce an adequate explanation for the concept of gravity in interviews conducted after the application. Barak & Zadok (2009) reported that having students create designs without giving any theoretical information about concepts relevant to the design or having students conduct research about this topic causes inadequate learning of concepts. It was revealed in this study that the process in which designs were made in conjunction with theoretical information generated more successful products. Sidawi (2009) also argued that students should go through training about concepts related to the design in order for a successful technological design to be created. It was concluded in the present study that there was lower increase in understanding level related to the concept of Gravity, about which no research was done, in comparison to increases in understanding levels related to Air Resistance, Terminal Velocity and Acceleration about which a wide range of research was done. Thus, it was determined that students should go through training about concepts within a designing process. It was concluded that elementary student teachers’ learnt science concepts better during technological design process.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

However, understanding the level concerning science concepts pertained to the design is directly associated with the method applied in the designing process. The fact that there was not an adequate increase in the levels of understanding of the concepts in the application in which no formal education was provided or no research was done brought about the conclusion that creating a technological design was not adequate by itself in the teaching of concepts. Accordingly, it is thought that if a technological design process is supported with theoretical information, desired change will occur in levels of understanding of the science concepts.

References

Barak, M., & Zadok, Y. (2009). Robotics projects and learning concepts in science, technology and problem solving. *International Journal of Technology and Design Education, 19*, 289– 307.

Barker, P., van Schaik, P., Hundson, S. & Tan, C. M. (1998). Mental Models and Their Role in Teaching and Learning, Proceedings of Ed-MEDIA/ED-TELECOM' 98 (World Conference on Educational Multimedia and Hypermedia and World Conference on Educational Telecommunications), Freiburg, GERMANY

Bencze, J. L. (2010). Promoting student-led science and technology projects in elementary teacher education: Entry into core pedagogical practices through technological design. *International Journal of Technology and Design Education*, *20*, 43–62.

Bierga, H., & Rasmussen, L. R. (2008). Enacting subjectivities in educational history: methodological reflections on the use of qualitative interviews for history writing.*Paedagogica Historica*, *44*(6), 721–731.

Brandt, R. (1998). Powerful learning. Association for Supervision and Curriculum, Alexandria, USA.

Chiou, C. C. (2008). The effect of concept mapping on students' learning achievements and interests. *Innovations in Education and Teaching International*, *45*(4), 375–387.

Çepni, S. (2010). Araştırma ve Proje Çalışmalarına Giriş (Genişletilmiş dördüncü baskı), Celepler Matbaacılık, Trabzon

Frazier, W., M. & Sterling, D., R. (2008). Motor Mania: Revving Up for Technological Design, *The Technology Teacher*, February, 5-12.

Hakkarainen, P.S., Viilo, M. & Hakkarainen, K. (2010). Learning by collaborative designing: technology-enhanced knowledge practices. *International Journal of Technology and Design Education*, *20*, 109–136.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.

Hay, D., Kinchin, I., & Baker, S. L. (2008). Making learning visible: the role of concept mapping in higher education. *Studies in Higher Education, 33*(3), 295–311.

Howard-Jonesa, P.A., Winfield, M. & Crimmins, G. (2008). Co-constructing an understanding of creativity in drama education that draws on neuropsychological concepts.*Educational Research, 50*(2), 187–201.

ITEA, International Technology Education Association. (2003). Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards. Reston, Virginia: ITEA.

ITEA, International Technology Education Association. (2007). Standards for Technological Literacy: Content for the Study of Technology. Third Edition, Reston, Virginia: ITEA.

Kinchin, I.M., Streatfield, D. & Hay, D.B. (2010). Using Concept Mapping to Enhance the Research Interview. *International Journal of Qualitative Methods, 9*(1), 52-68.

Liu, M. C. & Wang, J. Y. (2010). Investigating Knowledge Integration in Web-based Thematic Learning Using Concept Mapping Assessment. *Educational Technology & Society, 13*(2), 25–39.

Mettas, A., C. & Constantinou, C. C. (2007). The Technology Fair: A Project-Based Learning Approach For Enhancing Problem Solving Skills and Interest in Design and Technology Education, I*nternational Journal of Technology and Design Education, 18,* 79-100.

Miles, M. B. & Huberman, A.M. (1994). *Qualitative Data Analysis* (Second Edition), London: Sage.

Mioduser, D. & Dagan, O. (2007). The effect of the alternative approaches to design instruction (structural or functional) on students' mental models of technological design process, *International Journal Technological Design Education, 17*,135-148.

Moore, V., J., Chessin, D., A. & Theobald, B. (2010). Insect Keepers A Unit For First-and Second-Grade Students Integrates Life Science and Technological Design,*Science and Children*, March, 28-32.

Nugent, G., Barker, B., Grandgenett, N. & Adamchuk, V., I. (2010). Impact of Robotics and Geospatial Technology Interventions on Youth STEM Learning and Attitudes,*Journal of Research on Technology in Education, 42*(4), 391-408.

Oliver, K. & Hannafin, M. (2001). Developing and refining mental models in open-ended learning environments: A case study, 49(4), 5-32.

Roth, W. M. (2001). Learning science through technological design, *Journal of Research in Science Teaching, 38*(7), 768-790.

Safayeni, F., Derbentseva, N. & Canas, A. J. (2005). A theoretical note on concepts and the need for cyclic concept maps. *Journal of Research in Science Teaching 42*(7),741–766.

Sidawi, M. (2009) Teaching science through designing technology. *International Journal of Technology & Design Education*, *19*(3), 269-287.

Silk, E.M., Higashi, R., Shoop, R. & Schunn, C. D. (2010). Designing Technology Activities that Teach Mathematics, *The Technology Teacher*, December/January, 21-27.

Trigueros, M., & Martínez-Planell, R. (2010). Geometrical representations in the learning of two-variable functions. *Educational Studies in Mathematics*, *73*, 3–19.

Tsaparlis, G., & Papaphotis, G. (2009). High-School Students' Conceptual Difficulties and Attempts at Conceptual Change: The case of basic quantum chemical concepts,*International Journal of Science Education*, *31*(7), 895–930.

White, R., & Gunstone, R. (1992). *Probing Understanding*, Falmer Press, USA.

Wu, H. & Hsieh, C. (2006). Developing sixth graders' inquiry skills to construct explanations in inquiry-based learning environments. *International Journal of Science Education*, *28*(11), 1289-1313.

Yıldırım, A & Şimşek, H., (2003). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri*. Ankara: Seçkin Yayıncılık.

Copyright (C) 2013 HKIEd APFSLT. Volume 14, Issue 1, Article 2 (Jun., 2013). All Rights Reserved.