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The Impact of FeTeMM Activities on 7th Grade Students' Reflective Thinking Skills for Problem Solving Levels and their Achievements

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Abstract
This study aims to identfiy the impact of FeTeMM (Science and Technology, Engineering and Mathematics) activities on 7th grade students' reflective thinking skills for problem solving, academic achievement at math course. The sampling includes 60 students in the 7th grade attending school during the second term of 2015-2016 academic year. A quasi-experimental research design with two groups pre-test/post- test quantitative methods was used. There were 32 female and 28 male students. 32 students were classified as experimental group and 28 students as control group. The data were collected using " Reflective Thinking Skills for Problem Solving Scale", and " Achievement Test". During quantitative analysis, t test was used to identify the frequency, mean, median, mode, standard deviation and independent groups. The results of the study indicate that the students' academic achievement and reflective thinking skills for problem solving have improved. According to t test analysis, there were significant differences between experimental and control group. Some recommendations were suggested according to the results.

Key words:FeTeMM, Problem solving skills, Math achievement

Introduction

The fast-changing, increasing and transforming needs along with today's rapid population growth and developing technology require a more innovative and interdisciplinary educational system that could raise well-educated individuals to meet these needs. This new system should be sophisticated enough to solve the daily problems encountered by students of our century and make them qualified and competent to contribute to meet the needs of the society in which they live. That could be possible only when educational activities to teach these skills are integrated into the system. In recent years, FeTeMM education which has been practiced widely abroad but is new for our country serves this purpose and there aren't many studies in this area.

FeTeMM stands for Fen (Science), Teknoloji (Technology), Mühendislik (Engineering), Matematik (Mathematics). It is an educational approach that requires basically teaching of these disciplines altogether. This togetherness refers to integration and can be

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explained in two ways: Integrating more than one discipline into an activity (content integration)or using a discipline as the core part of the activity and taking advantage of other disciplines to teach the core discipline's context (contextual integration) (Moore, Stohlmann, Wang, Tank and Roehrig, 2014). It can be concluded that FeTeMM education is a precursor of a change or shift from being comprised of science, maths, technology and engineering as seperate disciplines to an integrated, multidisciplinary system (Riechert& Post, 2010).

FeTeMM education aims to realize holistic learning by relating different disciplines to each other (Smith&Karr-Kidwell, 2000). In FeTeMM education, the content is based on real life problems and efforts are made to integrate these problems into science, maths, technology and engineering. The integration could be doneeither by combining these four disciplines altogether or at least two of them. The integration of different disciplines into one system not only enables individuals to have holistic and multi-level viewpoints about the problems and events around them but also find creative solutions to them. (Roberts, 2012; Şahin, Ayar&Adıgüzel, 2014). FeTeMM education is important in that it can create an interdisciplinary point of view which is one of the necessary characteristics to lead the way in scientific area and economic.(Laceyve Wright, 2009).

The concept of integration in FeTeMM education raises questions about how it could be done and what the cahllenges could be encountered while doing it. FeTeMM's integration into a curriculum is more complicated and difficult than to establish relationships with other subjects around the contents of a subject.Bybee (2010) has reported that one of the most significant challenges in FeTeMM educational practice isthe integration of technology and engineering into the curriculum.

The neccessary qualities to raise individuals who are willing to carry out their duties against the social, economic, cultural and political prblems of todays' comptetitive world are considered as 21th century skills (NRC, 2009). Several different researchers have suggested similar views as to what sort of skills they are, although these skills prominent in a variety of sciences including scientific, social and human disciplines are hard to be defined in a single term.

After several interviews with some institutions, Wagner (2008) concluded that these special skills were (a) critical thinking and problem solving, (b) cooperationand leadership, (c) flexible thinking processes and adaptability, (d) being inititative and entrepreneurship (e) effective verbal and written communication, (f) accessing and analysing data and (g) curiosity and imagination. Bybee (2010) and Winds¬chitl (2009) proposed (1) adaptability, (2) communicative ability, (3) ability to solve any problem, (4) self-efficacy and self-development and (5) thinking within a systematical framework. Accordingly, the necessity of having and using these skill in daily life makes Fe¬TeMM education more important than ever.

FeTeMM education is based on original learning activities aiming to gain such skills as researching, inquiring, designing, problem solving, cooperation and participating in teamwork, efffective communication and producing things rather than learning independently the subjects found in its name.FeTeMM education also includes activities that will enhance the success and motivation of students in science and technology, enginneering and maths by using 21th century information and skills.

Lietrature review reveals that the studies are mainly about the integration of maths and science as well as science and engineering, students' academic success and the effects on their attitudes and perceptions of FeTeMMdisciplines.One of these researchers, Fortus et al. (2004) examined the effect of FeTeMM education on the change in learning levelsof 10thand 11th grade students. They found that activitiesbased on designing had a positive potential for students and an incontestable effect on their science learning and suggested that scientific curricula in schools be restructured according to learning by designing.

Wendell et al. (2010) designed a programme containing LEGOs to teach scientific topics within engineering designing framework and found that this programme proved very effective in learning scientific topics. Doppelt et al. (2008) examined the effect of FeTeMM education on learning levels of 8th grade students classified as those with high academic success and those with low academic success and concluded that FeTeMM education influenced students' interest in scientific topics positively and enhanced their curiosity and success. Apedoe et al. (2010) performed an 8-week program of chemistry topics such as atomic interactions, reactions and energy change at high school by combining design–based learning, engineering design and basics of scientific researchwith an engineering viewpoint. Roth (2001) taught 6th and 7th grade students simple machines in an engineering perspective and observed that this practice improved students' understanding of simple machines. Mooreet al. (2013) examined the role of engineering in FeTeMM education its eclectic properties and used samples of engineering adapted to science classes, concluding that FeTeMMeducation could have a potential for drawing students' attention to the lesson.

These studies supporting and encouraging FeTeMM education have shown that the relationships between scientific disciplines, mathematics, engineering and technology are important in establishing educational standards.(International Technology Education Association, 1999; Massac¬husetts Department of Education, 2006). There are many studies about FeTeMM activity programs commonly practicedabroad but there aren't any studies on it in Turkey.

In academic studies and surveys it is clear that the process of integration has mainly been focused on the science lessons along with one or more than one disciplines and its effects on different variables have been explored. However, it is noteworthy that the integration with maths hasn't been studied yet. The research problem is linked to this fact. The research questions are in the following:

(1) To what extent do FeTeMM activities influence the academic success among 7th grade students at maths?
(2) (To what extent do FeTeMM activities influence the reflective thinking skills for problem solving among 7th grade students?

Method

Study Design

A quasi-experimental research design with two groups pre-test/post- test quantitative methods was used in the study. The experimental design is used to test the cause-effect relationship between the variables (Cohen &Manion, 1997; Fraenkel&Wallen, 1996; Gay &Airasian, 2000). The difference between pre-test and post test means show the impact of independent variable on the dependent variable (Cohen &Manion, 1997; Gay &Airasian, 2000).

Participants

The study was conducted among 7th grade students attending a secondary school in Ankara in the second term of 2015-2016 academic year. There were 60 students in the study. There were 32 female and 28 male students. 32 students were classified as experimental group and 28 students as control group.

Data Collection

The data were collected using " Reflective Thinking Skills for Problem Solving Scale", and " Achievement Test". A pre-test and a post-test were conducted to identify the effects of FeTeMM activities on achievement at maths.

Data Analysis

First of all, a normal distribution of the data was checked. The independent sample t test was used to identify the differences between the groups.

Practising FeTeMM Activities

Four activities were performed respectively in the following:

- Let's make our clock
- Building a circular racing circuit model
- Designing an heat-insulated geometrical house model
- Let's discover pressure through prisms
- One of the activitiesperformed has been described in detail below.

Let's make our clock

A famous clock brand wants to produce a new series of clocks. The firm is calling for a national competition to choose clock models. The jury is going to select the best designs according to the given criteria to add them into the collection. You can participate in the competition by preparing your own exclusive clock model.The most important point is that the clock must be a circular one and instead of the numbers,the symbols of the elements corresponding to that numbers must be used by designers.

- Scientific dimension: the symbols of the elements
- Mathematical dimension: angles of a circle, area and perimeter of a circle and circular sector,
- Technological dimension: choosing materials, costs and utility
- Engineering dimension:design and production
- Problem:can you design an original clock according to the given criteria and size by thinking like a designer?

Requirements:

- The clock must be circular

- The clock must be designed exclusively.
- Any material cn be used.
- The length of an arc between two successive hours must be 5 cm
- The numbers must be replaced by the symbols of elements.
- The cost of the clock must not be more than 10 Turkish liras.

The production of the clock:

- write down any ideas about the solution of the problem.
- choose the best one among them
- draw your imaginary clock
- write the materials to be used on a piece of paper
- plan your design and do it
- test your design
- think about how you can improve your design.
- if you alter your design, repeat the steps done before.

Figures 1-2. Sample clocks from "Let's make our clock" activity

Figure 1

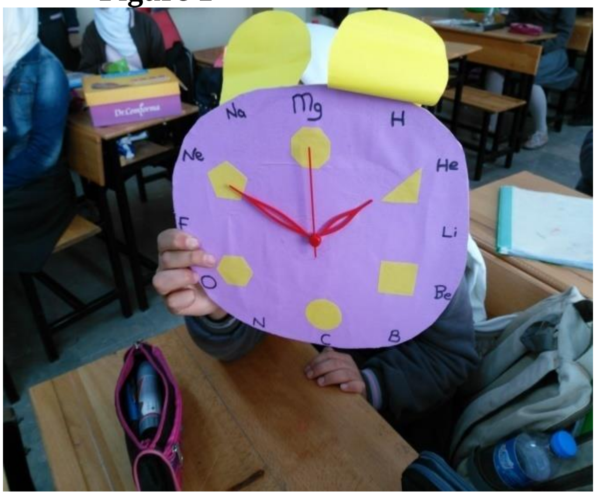
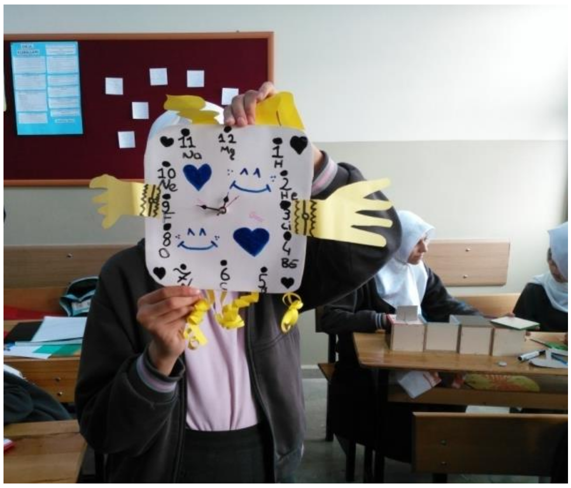


Figure 2



The aspects of mathematical, scientific and engineering topic were explored in relation to each other in the activities. In the first activity, a clock was produced by combining the topics "angles of a circle and calculation of an arc in a circle" in maths andthe topic "elements" in science by the students who designed their own imaginary clocks using technological equipments.

In the second activity, a circular racing circuit was produced by combining the topic " calculation of a circle and its sector's area"in maths and the topic "velocity, time and distance" in science by the students who integrated these topics to form a racing speedway.

In the third activity, a convenient and technological house model was produced by combining the topic " using tetragons in polygons and calculation of area in tetragons" in maths and the topic "heat insulation" in science by the students.

In the fourth activity,the topic "areas of polygons" in maths andthe topic "pressure" in science were integrated together.

During the activities, all students were instructed clearly and checked whether they fully understood what to do and produced a material in accordance with the objectives. The students collaborated with each other in groups to produce the materials. Thus, a sense of cooperation and collaboration was developed among them. The activities were performed in 2 lessons a week for 4 weeks.

Findings

Achievement

The students were tested before and after FeTeMM in terms of success level. An independent sample t test was run to reveal the achievement levels of the students.

Table 1. Independent Sample t-test result for achievement test

Measure Achievement	N	X mean	S	sd	t	p
Post-test control	26	41.84	8.59			
Post-test Experimental	27	49.88	14.10	51	2.49	0.025

According to independent sample t test, there is a significant difference in achievement test between the groups in favor of experimental group ($t(51)=2.49$, $p<0.05$). It can be concluded that the students' achievement has increased after FeTeMM activities.

Reflective Thinking Skills

"Reflective Thinking Skills for Problem Solving Scale" was administered to the students before and after FeTeMM activities. An independent sample t-test was run in order to explore the students' reflective thinking skills for solving problems. The findings are shown on Table 2.

Table 2. Independent Sample t-Test Result for reflective thinking skills for solving problems (YDBÖ)

Measure (YDBÖ)	N	Xmean	S	sd	t	p
Post-test control	26	2.73	0.96			
Post-test Experimental	27	2.63	0.51	51	0.48	0.00

Accordingto Table 2, there is a significant difference in the scale of reflective thinking skills for solving between grup in favor of experimental group ($t(51)=0.48$, $p<0.05$). It can be concluded from the data that the students' reflective thinking skills have improved after FeTeMM activities.

Discussion and Conclusion

1.It was found in the study thatFeTeMM activities contributed to students' academic success. There are several similar studies suggesting that FeTeMM activities enhanced the success and learning levels of the students (Fortus et al., 2004; Doppelt et al., 2008). In his study, Hartzler (2000) found that integrative FeTeMM activities contributed immeasurably to the students' success, interest and learning levels. Judson and Sawada (2000) examined the effect of integrating maths and science and found that this process improved the academic success.

2.The results of the study indicate thatFeTeMM activities improve the students' reflective thinking skills for solving problems. Likewise, Dewaters (2006) concluded that FeTeMM activities contributed to the solution of daily problems. Akins veBurghardt (2006) examined two schools teaching subjects based on logical-mathematical reasoning and found thatFeTeMM activities help the students learn maths, science and technology better or improve their explanation, analysis and prediction skills and the learning process is very effective.

Implications

(1) Activities related to FeTeMM should be used widespread in teaching and learning activities

(2) Teachers and school principals should be informed about FeTeMM education in seminars.

(3) Necessary equipment should be available to useFeTeMM activities actively in schools.

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