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The Effect of Science Centres on Students' Attitudes Towards Science

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The study, carried out in Ankara, Turkey, examined the effect of Middle East Technical University's Science Centre (METU SC) on students' attitudes towards science. The sample consisted of 251 students. The age range of the students varied from 11 to 14. The attitude scale was administered before, immediately after, and one week after a visit to METU SC. Because of the limitations on sampling procedure, two different research designs were used. Design 1 was a quasi-experimental design and arranged to determine the impact of METU SC on sixth graders' attitudes towards science with respect to the six constructs of the attitude scale, namely 'Learning science in school', 'Self-concept in school science', 'Practical work in school science', 'Science outside of school', 'Future participation in science', and 'Importance of science'. Design 2 was a weak experimental design and arranged to determine the impact of METU SC on students' overall attitudes towards science with respect to their gender, grade levels, and science achievement levels. The results of this study suggest that science centres might have high potential on increasing students' attitudes towards science in all dimensions of the attitude scale, except for 'Practical work in school science'. Furthermore, this increase is independent of gender, science achievement, and grade levels. Also, considering that this achievement was accomplished in quite a short time, science centres can be used by educators as an effective way of increasing students' attitudes towards science.

Keywords: *Science centres; Attitude towards science; Gender; Grade level; Science achievement*

Introduction

There is a common belief among people that science education is not necessary for all students. However, students need a basic understanding of general science concepts

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to apply them in everyday situations and give a response to scientific issues of our rapidly changing world (Jarvis & Pell, 2002). Furthermore, the decline in the number of highly qualified scientists has shown the importance of science education for all citizens (Her Majesty's Stationary Office, 1993). Unfortunately, many students find their science courses boring and impractical (Barmby, Kind, & Jones, 2008; Lyons, 2006). As Pedretti (2004) pointed out, 'This is not surprising as students wade through excessive content demands, usually void of context. Typically, science is presented as a corpus of knowledge to be mastered, memorized, and occasionally applied to the real world' (p. 40).

Most of the students' attitudes towards science start to decrease at the age of 11 during elementary schooling. A sharp decline is usually observed between the ages of 11 and 14 (Bennett & Hogarth, 2009; Kelly, 1986; Osborne, Simon, & Collins, 2003). Quite a number of studies have documented the possible factors affecting students' attitudes towards science. For example, Freedman (1997) showed that hands-on activity-based laboratory instruction improves students' attitudes towards science. Parents and peer encouragements on students' participation in science were also found to be important factors increasing students' attitudes towards science (Breakwell & Beardsell, 1992; Papanastasiou & Papanastasiou, 2004). Osborne et al. (2003) provided a fine picture of possible factors affecting students' attitudes by synthesizing the available literature. The major factors emerging from this synthesis were categorized as gender, classroom environment (e.g. involvement, personal support, positive relationships with classmates, and the use of a variety of teaching strategies), the quality of science teaching, students' positive experiences of extra-curricular activities, students' perception of science, students' task value beliefs, parental support, and attitudes of peers and friends.

Students' attitudes towards science has a special importance in science education not only because it predicts students' selection of science-related courses or careers in the future (Koballa, 1995; Koballa & Glynn, 2006; Sorge, Newsom, & Hagerty, 2000), but also because it correlates with students' academic performance (Germann, 1988; Sorge et al., 2000) and achievement in science (Mattern & Schau, 2002; Papanastasiou & Zembylas, 2002; Schibeci & Riley, 1986; Simpson & Oliver, 1990; Singh, Granville, & Dika, 2002; Webster & Fisher, 2000). Therefore, improving students' attitudes towards science is becoming an important issue for the community of science educators. Nevertheless, 'the affective area is much neglected in traditional, formal science education and this neglect might well contribute to reduced uptake of the sciences, shortages of scientists and technologists in industry, and gender division, particularly in the physical sciences' (Wellington, 1990, p. 250).

One way of overcoming the shortcomings of formal educational settings is to support students with informal (out-of-school) settings such as science centres, science and technology museums, cultural museums, nature centres, zoos, libraries, and open-air museums. Informal settings provide students with opportunities to get acquainted with real experiences about science without the pressure of getting assessed about their particular gains. One of the most important informal settings for science learning is perhaps science centres. Although the term science centre is

used in this study, there are quite a number of terms used in the literature, such as science and technology centres (Association of Science-Technology Centers [ASTC], n.d.), hands-on science centres (Bradburne, 1998; Wellington, 1990), hands-on science and technology centres (Pompea & Hawkins, 2002; Walton, 2000), interactive science centres (Wellington, 1990), interactive hands-on science centres (Ramey-Gassert, Walberg III, & Walberg, 1994), and interactive science and technology centres (Quin, 1990; Rennie & McClafferty, 1995). However, the researchers' descriptions and interpretations about these centres reveal that there is no significant difference among them. Janette Griffin from the University of Technology, Sydney, Australia (personal communication, January 12, 2009) states that the use of the terms is fairly loose and there is no major difference among them. In the most general sense, science centres can be defined as places where visitors are connected with science, given curiosity, wonder, encouragement, and firsthand experience (ASTC). One of the most distinguished characteristic of science centres is their ability to mix learning and entertainment (Weitze, 2003) by allowing visitors to touch, play, and experiment with the exhibits (Quin, 1990). A review of the literature reveals that science centres have positive effects on

- learning science (European Network of Science Centres and Museums [Ecsite], 2008; Falk & Needham, 2011; Garnett, 2001; Hooper-Greenhill et al., 2005; National Research Council [NRC], 2009; Rennie & McClafferty, 1995; Watson, Dodd, & Jones, 2007),
- understanding science (Anderson, Lucas, Ginns, & Dierking, 2000; Falk & Needham, 2011; Hooper-Greenhill et al., 2005; Pompea & Hawkins, 2002),
- motivation to learn about science (Ramey-Gassert et al., 1994; Watson et al., 2007; Wellington, 1990),
- science-related career choices (Garnett, 2001; NRC, 2009; Salmi, 2003),
- interest in science (Bozdoğan & Yalçın, 2006, 2009; Pompea & Hawkins, 2002; Wellington, 1990),
- scientific literacy (Pompea & Hawkins, 2002; Wellington, 1990),
- psychomotor skills (e.g. dexterity, manipulative skill, hand-eye coordination) (Wellington, 1990), and
- attitudes towards science (Ecsite, 2008; Falk & Needham, 2011; Garnett, 2001; Hooper-Greenhill et al., 2005; Jarvis & Pell, 2002, 2005; NRC, 2009; Ramey-Gassert et al., 1994; Rennie & McClafferty, 1995; Rix & McSorley, 1999; Russell, 1990; Wellington, 1990).

The purpose of this study is to inquire about the role of science centres on students' attitudes towards science. Although the studies about students' attitudes towards science go back to the 1960s (Osborne et al., 2003), studies about the role of science centres in students' attitudes is relatively new. Nevertheless, the results of the studies conducted since 1995 explicitly showed that science centres positively affect students' attitudes towards science. Table 1 summarizes the results of empirical studies about students' attitudes towards science in general and the role of science centres in students' attitudes.

Table 1. A summary of studies about students' attitudes towards science in general and the role of science centres in students' attitudes

Boys start off with more positive attitudes towards science than girls, but boys' attitudes drop faster than girls' as they progress through school.	George (2000, 2006)
Girl's attitudes towards science declined faster than boys' as they progress through school.	Barmby et al. (2008)
Boys' attitudes towards science are higher than girls'.	Breakwell and Beardsell (1992); Catsambis (1995); Francis and Greer (1999); Reid and Skryabina (2003); Simpson and Oliver (1990); Weinburgh (1995)
Girls' attitudes towards science are higher than boys'.	Baker and Leary (1995); Harwell (2000)
There is no difference between boys' and girls' attitudes towards science.	Dhindsa and Chung (2003); Greenfield (1997); Scantlebury et al. (2007)
Science centres have positive effects on students' attitudes towards science.	Jarvis and Pell (2002, 2005); Rennie and McClafferty (1995); Rix and McSorley (1999)
Girls' attitudes towards science are more positively affected by science centres than boys'.	Jarvis and Pell (2005)
Girls' attitudes towards science decline faster than boys' after visit to science centres.	Jarvis and Pell (2005)
Students' grade levels are inversely proportional to their attitudes towards science.	Barmby et al. (2008); Bennett and Hogarth (2009); Coughlan (2000); Francis and Greer (1999), George (2000, 2006); Kelly (1986); Koballa (1995); Muphy and Beggs (2003); Osborne et al. (2003); Reid and Skryabina (2003); Simpson and Oliver (1990) but opposite to the findings of Breakwell and Beardsell (1992) and Hassan (2008)
Students' SALs are directly proportional to their attitudes towards science.	Mattern and Schau (2002)

The intention of the current study is to contribute to the literature by elaborating the role of a science centre in students' attitudes towards science. This elaboration will be made in two different ways. First, 'attitude' will be analysed under several dimensions, in order to provide a clearer picture about the possible effects of a science centre on the sub-levels of attitude. Second, the interaction between several variables (e.g. gender, science achievement level (SAL), and grade level) and the effect of a science centre will be analysed with the intention of understanding whether the effect of a science centre depends on the variation of some specific variables.

Method

Research Questions

The purpose of this study is to determine whether there is a potential contribution of Middle East Technical University's Science Centre (METU SC) to students'

attitudes towards science and whether this contribution is related to students' gender, grade levels, or science achievements. More precisely, the researchers aimed to answer the following questions:

(1) Is there any effect of METU SC on students' attitudes towards science with respect to the six factors of the attitude scale?
(2) Is there any effect of METU SC on students' attitudes towards science with respect to their gender, grade levels, and SALs?

Setting: METU SC

METU SC came into existence in 2005 and has been serving in an independent building located in the campus of METU. It is one of the most popular science centres in Turkey and successful in attracting approximately 40,000 visitors per year. It serves everybody from all ages, cultures, educational levels, and backgrounds free of charge. Schools can also visit METU SC in groups based on a reservation system. The current study was conducted with students who visited METU SC in school groups. When school groups come to METU SC, they are given a presentation about METU and METU SC. Afterwards, the students are informed about 12 exhibits with a guide's interactive demonstrations referred to as a science show, during which the guide flashes out some of the important and interesting aspects of the exhibits. This show lasts approximately 40 minutes. After the show, students are let free in order that they can make their own observations and experiments. During students' free explorations, the guides walk through the students to help them engage in exhibits or answer their specific questions about the exhibits. Today, METU SC presents 52 interactive exhibits demonstrating the relevance of science with everyday life. In total, students spent approximately 90 minutes at the science centre for this research, and there was no significant variation among the students in terms of the time spent in the museum.

Research Design and Sampling

The sample of the current study was selected from METU SC's appointment list. The appointment list is a list of schools whose requests for visiting METU SC were confirmed. An ideal sample for the research questions would be two equivalent student groups of different grades. However, we could not identify such a sample from the appointment list. This limitation on the sampling procedure led the researchers to form two different research designs.

Design 1. Design 1 was a quasi-experimental design which was used to determine the effect of METU SC on sixth grade students' attitudes towards science in terms of the six factors of the attitude scale by obtaining the data across the three time periods; before, immediately after, and a week after the visit to METU SC. The sample of this design consisted of 92 sixth graders from the same school ($N = 46$ for the experimental and $N = 46$ for the control group). Students were assigned to the control or

experimental groups according to the availability of students' course schedule during the visit to METU SC. For each factor of the attitude scale, the research questions were formulated as follows:

(1) Is there a change in mean scores of sixth grade students' attitudes towards science (for each construct of the attitude scale) across the three time periods?
(2) Are there differences in mean scores of sixth grade students' attitudes towards science (for each factor of the attitude scale) between the experimental and control group across the three time periods?
(3) Is there a same change in mean scores of sixth grade students' attitudes towards science (for each factor of the attitude scale) across the three time periods for the different groups (the experimental and control group)?

Design 2. Design 2 was also a quasi-experimental design without a control group. This design was used to determine whether there is an effect of METU SC on students' attitudes towards science with regard to their gender, grade levels, and SALs. The sample of this design consisted of three intact groups of sixth ($N = 52$), seventh ($N = 55$), and eighth ($N = 52$) graders from the same school.

The following research questions were formulated to determine the gender effect on the effect of METU SC on students' attitudes towards science. The same formulation was used for the effects of grade levels and science achievements.

(1) Is there a change in students' mean attitude scores towards science across the three time periods?
(2) Is there an impact of gender type on mean attitude scores towards science?
(3) Is there a same change in mean attitude scores towards science across the three time periods for boys and girls?

Instruments

In this study, two instruments were used. One was an 'Information Collection Form' which was used to obtain demographic information about students (e.g. science achievement score, gender, age, and grade). The other instrument was the 'Attitude towards Science Scale', which was developed by Kind, Jones, and Barmby (2007) to obtain information about students' attitudes towards science in terms of several factors. The original scale (it can be obtained from Kind et al. (2007)) consists of 46 attitude statements. Even though the original scale has attitude statements towards schools (i.e. statements between the 38th and 46th items), these statements were removed because they are out of the scope of this study. Then, the researchers received expert ($N = 22$) opinions for the original scale's statements. The following statements were advised to be removed from the scale due to various reasons. The major reason was that the first and second items state particular conditions for an attitude that blocks students' expression of their attitudes unconditionally. The last item was advised to be removed simply because it is hard to make a direct connection between science and poverty.

(1) Practical work in science is good because I can work with my friends.
(2) I like practical work in science because I can decide what to do myself.
(3) Science and technology are helping the poor.

Moreover, the following statements were advised to be revised. The first item was reported to state a condition. For the second and third items, the experts claimed that while students may agree with the statement: 'I would like to have a job working with science', they may not agree with the statement: 'I would like to become a science teacher'. In this respect, these statements might conflict with each other, and may not reflect the true attitudes of students.

(1) I like science practical work because you don't know what will happen.
(2) I would like to have a job working with science.
(3) I would like to become a science teacher.

According to the experts' suggestions, the first statement 'I like science practical work because you don't know what will happen' was revised as 'I like science practical work'. The second and third statements were combined and a final statement was formulated as 'I would like to have a job working with science and technology'. With these modifications, the original scale was reduced to 33 items. The translations into Turkish and then back into English were carried out by the research assistants of the Faculty of Education ($N = 6$) and the Department of Basic English ($N = 3$) of METU. The most repeated translation statements were selected as the final statements in the scale. After the translation process, the scale was piloted with 114 students who came to visit METU SC.

The reliability coefficient (Cronbach α) of the attitude scale was found to be 0.94. Then, the scale was subjected to principal component analysis (PCA) by using SPSS. Prior to performing PCA, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of an adequate number of coefficients of 0.3 and above. The Kaiser–Meyer–Olkin value (0.86) exceeded the recommended value of 0.6 and Barlett's test of sphericity reached statistical significance, which supported the factorability of the correlation matrix (Pallant, 2005). PCA revealed the presence of six components with eigenvalues of over 1. Each component explained a considerable portion of the total variance (38.6%, 10.6%, 8.7%, 5.1%, 4.7%, and 3.5%). An inspection of the scatter plot revealed a clear break after the second component. Using Catcll's scree test, it was decided to retain six components for further investigation. To elaborate the interpretation of these six components, varimax rotation was performed. The rotated solution (presented in Table 2) revealed the presence of a simple structure with six components. It also revealed a number of strong loadings with all variables loading substantially on only one component. By examining the descriptions of the factors proposed by Kind et al. (2007), six factors were labelled as 'Self-Concept in School Science', 'Science Outside of School', 'Practical Work in School Science', 'Learning Science in School', 'Future Participation in Science', and 'Importance of Science'.

Table 2. Eigenvalues, percentages of variance, and cumulative percentages for factors of the 33-item attitude scale

Factor	Eigenvalue	% of variance	Cumulative %
1	12.7	38.6	38.6
2	3.5	10.6	49.2
3	2.9	8.7	57.9
4	1.7	5.1	63.0
5	1.5	4.7	67.7
6	1.2	3.5	71.2

Procedures of Data Collection

For both of the research designs, pre-, post-, and retention tests were administered at weekly intervals for three weeks during the spring semester of 2009. While the students in the experimental group were visiting METU SC during the second week, the students in the control group continued their regular activities in their school. All students were informed in advance that they would all take a visit to METU SC in different time intervals.

Data Analyses

Before running the detailed analyses, the data were controlled in order to identify erroneous entries. One student did not fill out the attitude scale for the post-test measure, while five students did not fill out the attitude scale for the retention test measure. These students were removed from the study. Thus, the sample size decreased to 251 students. Every participant provided a score representing her/his attitude before the experimental manipulation (visit to METU SC), immediately after the manipulation, and one week after the manipulation. In other words, the data were collected repeatedly at one week intervals throughout three weeks. The reliability coefficients of the attitude scale for the three measurements were provided in Table 3.

The repeated measure design was used in order to answer the research questions. The process of the analysis is summarized in Figure 1. Besides, the researchers used paired-samples *t*-tests in order to elaborate the possible effects of experimental manipulation. The adjustment for the level of significance for paired-samples *t*-tests was checked according to the Bonferroni correction significance level. The corrected

Table 3. The reliability coefficients of attitude scale for three measurements

	Time 1	Time 2	Time 3
Design 1 ($N = 92$)	0.94	0.95	0.95
Design 2 ($N = 159$)	0.94	0.94	0.94
Overall ($N = 251$)	0.94	0.94	0.95

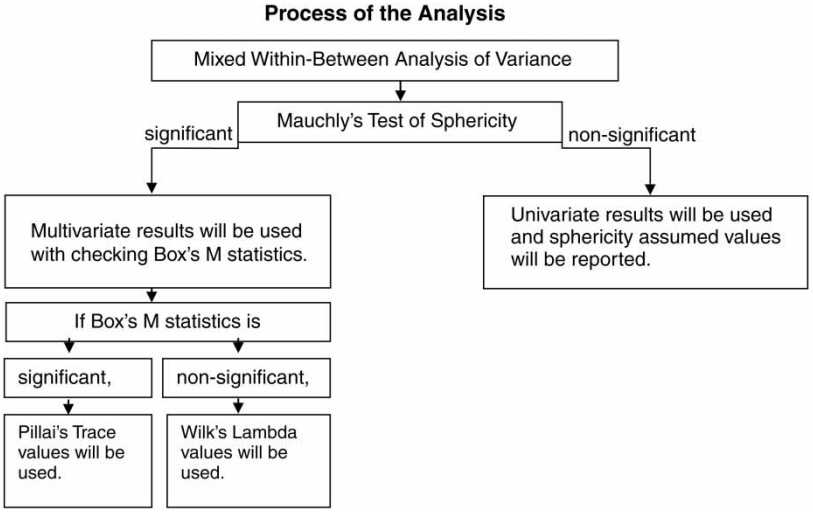

Figure 1. Process of the analysis (adapted from Field, 2005).

significance level was calculated as 0.017 (0.05/3). The following equation was used in the calculation of the effect sizes for paired- samples *t*-tests (Pallant, 2005, p. 212) and to interpret the calculated values the following criteria were used: 0.01 = small effect, 0.06 = moderate effect, and 0.14 = large effect.

$$\eta^2 = \frac{t^2}{[t^2 + (N-1)]}, \quad (N-1) = \mathrm{df}(\text{degrees of freedom})$$

Results of Design 1

A mixed within-between analyses of variances were conducted to analyse the effect of METU SC on students' attitudes towards science with regard to six factors of the attitude scale. The group by time interactions were analysed with respect to the six factors of the attitude scale. Descriptive statistics of demographic variables were also summarized in Table 4.

(1) Learning Science in School

For the factor of learning science in school, Mauchly's test indicated that the assumption of sphericity was violated, χ^2 (2) = 19.76, $p = 0.000 < 0.0005$. Box's *M*-statistics was also violated, Box's $M = 19.01$, $p = 0.005 < 0.050$. Therefore, we checked for Pillai's trace which showed a significant group by time interaction effect (Pillai's trace = 0.07, $F(2,89) = 3.38$, $p = 0.038 < 0.050$, $\eta^2 = 0.62$ indicating a very large effect size). This result revealed that the change in mean attitude related to learning science in school over time was not the same for experimental and control groups. The estimated marginal means of attitude graph (Figure 2)

Table 4. Descriptive statistics of demographic variables

	Total		Experimental group		Control group	
	N	%	*N*	%	*N*	%
Gender						
Male	47	51.1	20	43.5	27	58.7
Female	45	48.9	26	56.5	19	41.3
Age						
11	3	3.3			3	6.5
12	61	66.3	33	71.7	28	60.9
13	27	29.3	13	28.3	14	30.4
14	1	1.1			1	2.2
SAL						
Fail	5	5.4	2	4.3	3	6.5
Passable	11	12.0	4	8.7	7	15.2
Average	27	29.3	13	28.3	14	30.4
Good	30	32.6	13	28.3	17	37.0
Excellent	19	20.7	14	30.4	5	10.9
Total	92	100	46	100	46	100

Note: SAL, science achievement level.

illustrated that the mean attitude scores of the students in the control group decreased over time. Those of the students in the experimental group, whereas, fluctuated. Their mean attitude scores were highest after the visit (($M = 26.09$, SD $= 4.19$), t $(45) = -2.71$, $p = 0.010$, $\eta^2 = 0.14$ indicating a large effect), and decreased one week later (($M = 25.61$, SD $= 3.86$), t $(45) = -0.95$, $p = 0.346$, $\eta^2 = 0.02$ indicating a small effect). This result revealed that METU SC has a positive effect on students' attitudes related to learning science in school.

(2) Self-concept in School Science

Mauchly's test indicated that the assumption of sphericity was not violated, χ^2 $(2) = 0.39$, $p = 0.824 > 0.050$. Therefore, we checked for 'sphericity assumed' results which showed a significant group by time interaction effect ($F(2,180) = 4.90$, $p = 0.008 < 0.050$, $\eta^2 = 0.05$ indicating a small effect). This result revealed that the change in mean attitude scores related to self-concept in school science across the three time periods was not the same for the experimental and control groups. The estimated marginal means of attitude graph (Figure 3) illustrated that self-concept scores of the students in the control group almost never changed; whereas, those of the students in the experimental group changed over time. Their self-concept scores were highest after the visit (($M = 29.07$, SD $= 5.41$), t $(45) = -4.42$, $p = 0.000$, $\eta^2 = 0.30$ indicating a very large effect), and decreased one week later (($M = 27.93$, SD $= 5.96$), t $(45) = 1.62$, $p = 0.113$, $\eta^2 = 0.06$ indicating a moderate effect size). In spite of the

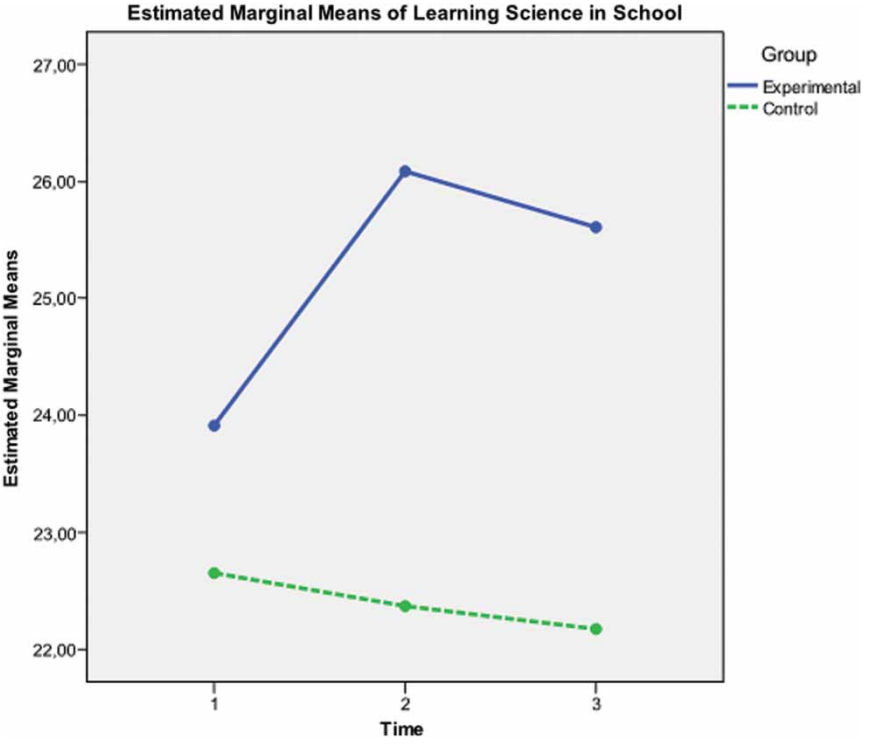

Figure 2. The comparison of estimated marginal means of attitude related to learning science in school across the three time periods for the experimental and control groups

decrease, students' self-concept scores were still significantly higher than the scores measured before the visit. This result suggested that METU SC has a positive effect on changing students' attitudes related to self-concept in school science.

(3) Practical Work in School Science

Mauchly's test indicated that the assumption of sphericity was not violated, χ^2 (2) = 0.165, $p = 0.\ 921 > 0.050$. Therefore, we checked for 'sphericity assumed' results which showed a non-significant group by time interaction effect ($F(2,80) = 2.63$, $p = 0.075 > 0.050$, $\eta^2 = 0.03$ indicating a small effect). This result suggested that the overall change in practical work scores over time is statistically the same for experimental and control groups. The estimated marginal means of graph (Figure 4) illustrated that the mean practical work scores of the students in the control group never changed over time. Those of the students in the experimental group, whereas, fluctuated over time. Their mean attitude scores were highest after the visit (($M = 27.37$, SD = 3.21), t (45) = −2.76, $p = 0.008$, $\eta^2 = 0.15$ indicating a large effect), and one week later, it appeared that their mean scores decreased (($M = 26.26$, SD = 5.14), t (45) = 1.55, $p = 0.128$, $\eta^2 = 0.05$ indicating a small effect size). This result suggested that there was a positive impact of METU SC on changing

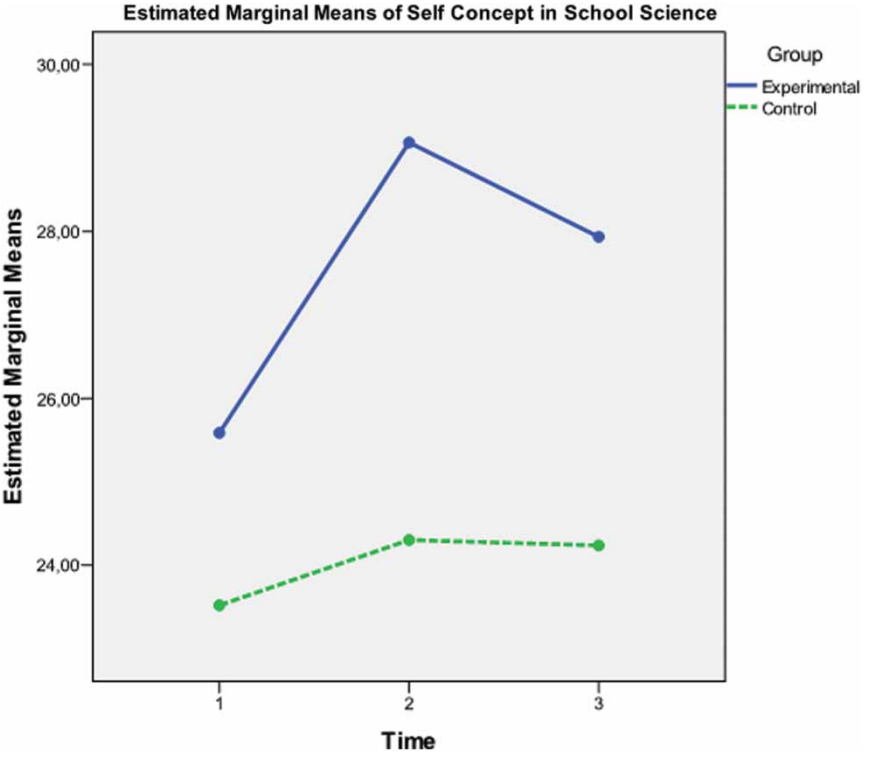

Figure 3. The comparison of estimated marginal means of attitude related to self-concept in school science across the three time periods for the experimental and control groups

students' attitudes related to practical work in school science. However, students' mean scores measured one week later were not significantly higher than those measured before the visit. This result suggested that METU SC is not effective in changing students' attitudes related to practical work in school science due to the fact that this impact is temporary.

(4) Science Outside of the School

Mauchly's test indicated that the assumption of sphericity was not violated, χ^2 (2) = 5.14, $p = 0.076 > 0.050$. Therefore, we checked for 'sphericity assumed' results which showed a significant group by time interaction effect ($F(2,180) = 6.08$, $p = 0.003 < 0.050$, $\eta^2 = 0.06$ indicating a moderate effect). This result revealed that the change was not the same in mean attitude scores related to science outside of school over time for both groups. The estimated marginal means of attitude graph (Figure 5) illustrated that the mean scores of the students in the control group almost never changed over time; whereas, those of the students in the experimental group fluctuated over time. Their mean attitude scores were highest after the visit (($M = 27.52$, SD = 3.30), t (45) = −5.55, $p = 0.000$, $\eta^2 = 0.41$ indicating a very

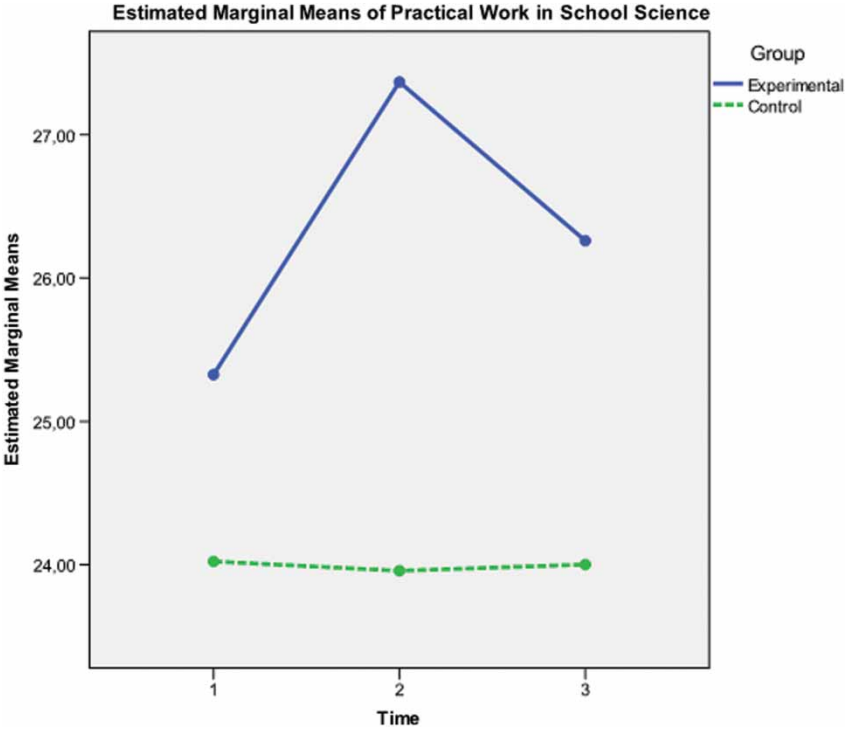

Figure 4. The comparison of estimated marginal means of attitude related to practical work in school science across the three time periods for the experimental and control groups

large effect), and decreased one week later (($M = 27.09$, SD $= 3.63$), t (45) $= 0.90$, $p = 0.375$, $\eta^2 = 0.02$ indicating a small effect size). However, the scores measured one week later were still significantly higher than those measured before the visit. This result suggested that METU SC has a positive effect on changing students' attitudes related to science outside of school.

(5) Future Participation in Science

Mauchly's test indicated that the assumption of sphericity was not violated, χ^2 (2) $=$ 0.34, $p = 0.844 > 0.050$. Therefore, we checked for 'sphericity assumed' results which showed a significant group by time interaction effect ($F(2,180) = 3.48$, $p =$ $0.033 < 0.050$, $\eta^2 = 0.04$ indicating a small effect). This result revealed that the change in mean attitude scores related to future participation in science across the three time periods was not the same for the experimental and control groups. The estimated marginal means of attitude graph (Figure 6) illustrated that the mean scores of the students in the control group slightly increased over time. However, these increases were not statistically significant. The scores of the students in the experimental group fluctuated over time. Their mean scores were the highest after the visit (($M = 17.57$, SD $= 3.10$), t (45) $= -4.20$, $p = 0.000$, $\eta^2 = 0.28$ indicating a

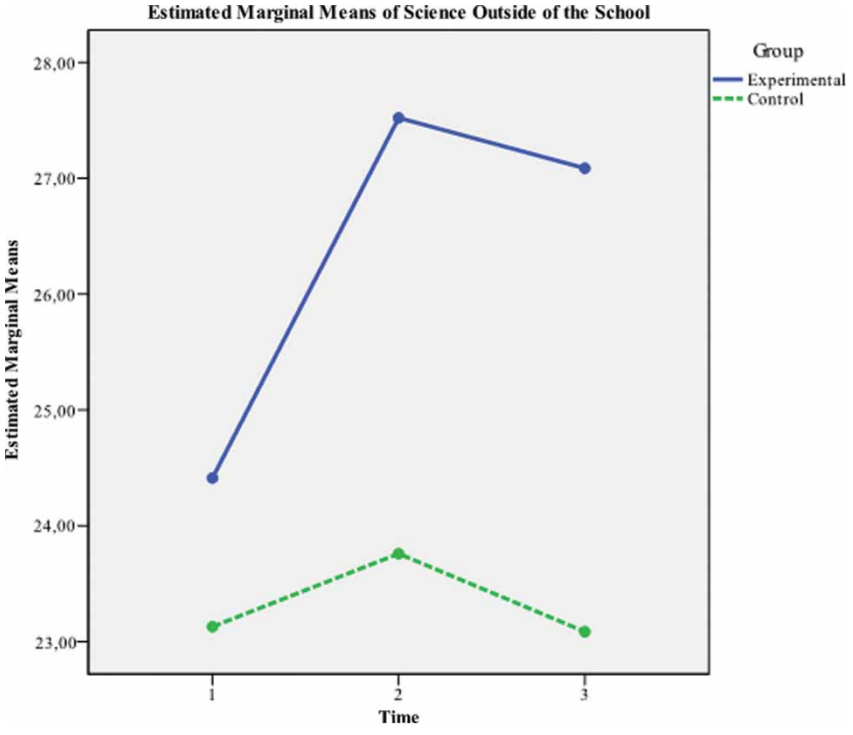

Figure 5. The comparison of estimated marginal means of attitude related to science outside of school across the three time periods for the experimental and control groups

very large effect) and slightly decreased one week later. Nevertheless, the mean scores measured one week later were still significantly higher than those before the visit (($M = 17.26$, SD = 3.40), t (45) = 0.52, $p = 0.603$, $\eta^2 = 0.006$ indicating a small effect size). This result suggested that METU SC has a positive effect on changing students' attitudes related to future participation in science.

(6) Importance of Science

Mauchly's test indicated that the assumption of sphericity was violated, χ^2 (2) = 17.61, $p = 0.000 < 0.050$. Box's M statistics was also violated, Box's $M = 20.17$, $p = 0.003 < 0.050$. Therefore, we checked for Pillai's trace which showed a significant group by time interaction effect (Pillai's trace = 0.16, $F(2,89) = 8.66$, $p = 0.000 < 0.0005$, $\eta^2 = 0.16$ indicating a large effect size). This result revealed that the change in mean attitude scores related to importance of science across the three time periods was not the same for the experimental and control groups. The estimated marginal means of attitude graph (Figure 7) illustrated that the mean scores of the students in the control group decreased at the second measurement, and stayed the same at the third measurement; whereas, those of the students in the experimental group increased across the three time periods (e.g. from Time 1 ($M = 16.57$, SD = 2.93)

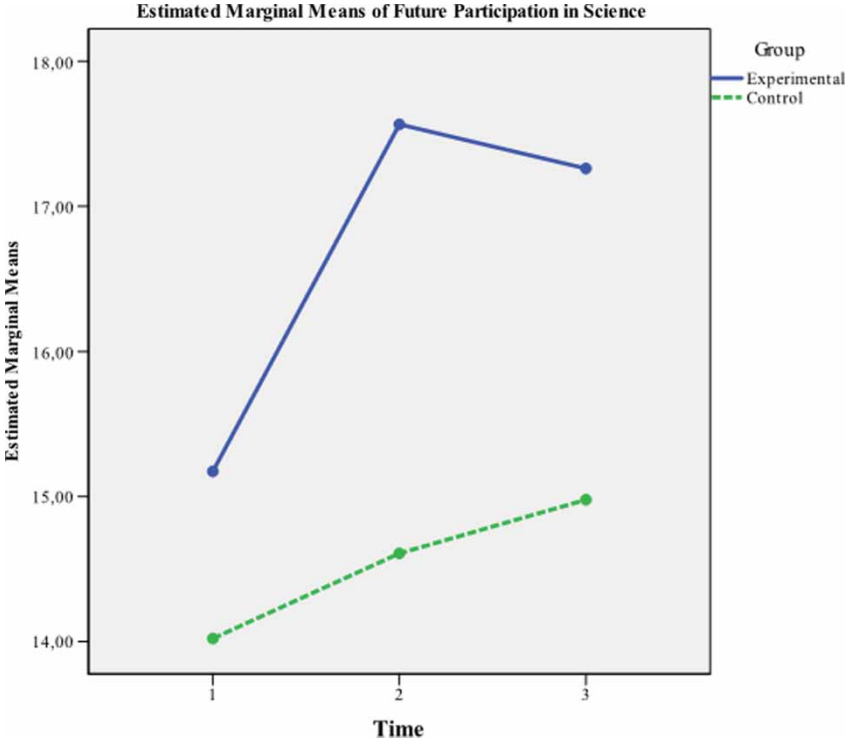

Figure 6. The comparison of estimated marginal means of attitude related to future participation in science across the three time periods for the experimental and control groups

to Time 2 (($M = 18.09$, SD $= 2.87$), $t\,(45) = -3.32$, $p = 0.002$, $\eta^2 = 0.20$ indicating a very large effect). This result suggested that METU SC has a positive effect on changing students' attitudes related to importance of science.

Results of Design 2

The purpose of design 2 was to determine the effect of METU SC on students' attitudes towards science with regard to their gender, grade levels, and SALs. Descriptive statistics of the demographic variables were summarized in Table 5.

A mixed within-between analysis of variance was conducted to compare the effect of science centre on students' attitudes towards science with regard to their gender, grade levels, and SALs (Figure 8). Mauchly's test indicated that the assumption of sphericity was not violated, $\chi^2\,(2) = 2.23$ $p = 0.329 > 0.050$. Therefore, sphericity assumed F tests for time, gender, grade levels, and SALs were used. The results were provided in Table 6.

A mixed-model analysis of variance revealed that the main effect for time was significant ($F(2,306) = 81.62$, $p = 0.000 < 0.0005$, $\eta^2 = 0.35$ indicating a very large effect size), which means that visit to METU SC significantly changed students' attitudes towards science. Further analysis with Bonferroni pairwise comparisons revealed that

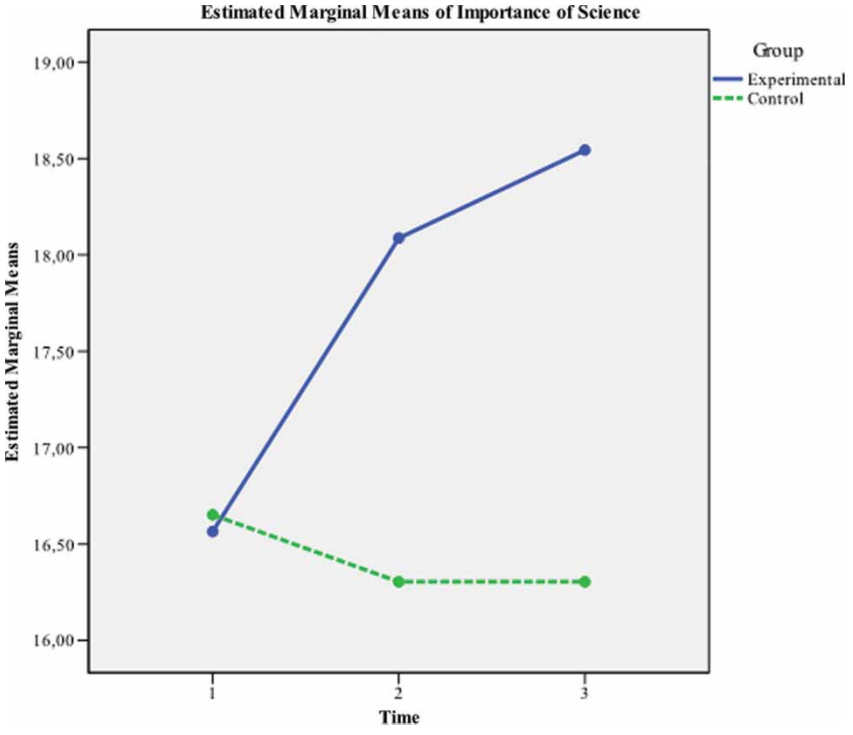

Figure 7. The comparison of estimated marginal means of attitude related to importance of science across the three time periods for the experimental and control groups

there was a significant increase in mean attitude scores from Time 1 ($M = 128.32$, SE $= 1.55$) to Time 2 ($M = 140.04$, SE $= 1.17$). Similarly, there was a significant difference between Time 1 ($M = 128.32$, SE $= 1.55$) and Time 3 ($M = 137.54$, SE $= 1.40$). However, there was a significant decrease in mean attitude scores from Time 2 ($M = 140.04$, SE $= 1.17$) to Time 3 ($M = 137.54$, SE $= 1.40$) (Figure 8).

To understand whether the effect of METU SC differs between male and female students, time by gender interaction was analysed. According to the F test results, there was no significant time by gender interaction ($F(2,306) = 1.60$, $p = 0.204 > 0.050$, $\eta^2 = 0.010$ indicating a small effect). This result showed that the change in mean attitude scores over time was statistically the same for boys and girls (Figure 8).

There was also no significant time by grade interaction effect ($F(4,306) = 0.61$, $p = 0.656 > 0.050$, $\eta^2 = 0.01$ indicating a small effect). This indicated that the change in mean attitude scores of students in different grade levels over time was statistically the same (Figure 8).

Similarly, there was no significant time by SAL interaction ($F(4,306) = 1.41$, $p = 0.232 > 0.050$, $\eta^2 = 0.02$ indicating a small effect). This result suggested that the change in mean attitude scores of students with different SALs over time was statistically the same. This result suggested that METU SC influences the students in different SALs equally on changing their attitudes towards science (Figure 8).

Table 5. Descriptive statistics of demographic variables

	N	%
Gender		
Male	84	52.8
Female	75	47.2
Age		
12	56	35.2
13	53	33.3
14	50	31.4
Grade		
Sixth	52	32.7
Seventh	55	34.6
Eighth	52	32.7
SAL		
3 (average)	49	30.4
4 (good)	54	34.0
5 (excellent)	56	35.2
Total	159	100

Note: SAL, science achievement level.

Table 6. Analysis of variance results for effects

Source	SS	df	MS	*F*	η^2
Time	12028.28	2	6014.14	81.62*	0.34
Time * Gender	235.81	2	117.90	1.60	0.01
Time * Grade	179.65	4	44.91	0.61	0.01
Time * SAL	414.26	4	103.56	1.41	0.02
Error (time)	22548.78	306	73.69		

*$p < 0.017$.

Discussion

The current study has highlighted a variety of issues concerning the effect of a science centre on students' attitudes towards science. The results of the study explicitly showed that METU SC has a positive effect on changing primary education students' attitudes towards science. This result is consistent with the findings in the literature (e.g. Jarvis & Pell, 2002, 2005; Rennie & McClafferty, 1995; Rix & McSorley, 1999). Several researchers also reported evidence that the positive changes in visitors' attitudes were maintained for a long period of time (Ecsite, 2008; Jarvis & Pell, 2002, 2005). However, in this study, students' overall attitudes towards science declined just a week after the visit to METU SC. Osborne et al. (2003) have pointed out that students' attitudes towards science can be affected by several factors, such as their curricular/extra-curricular activities, parental support, or attitude of friends.

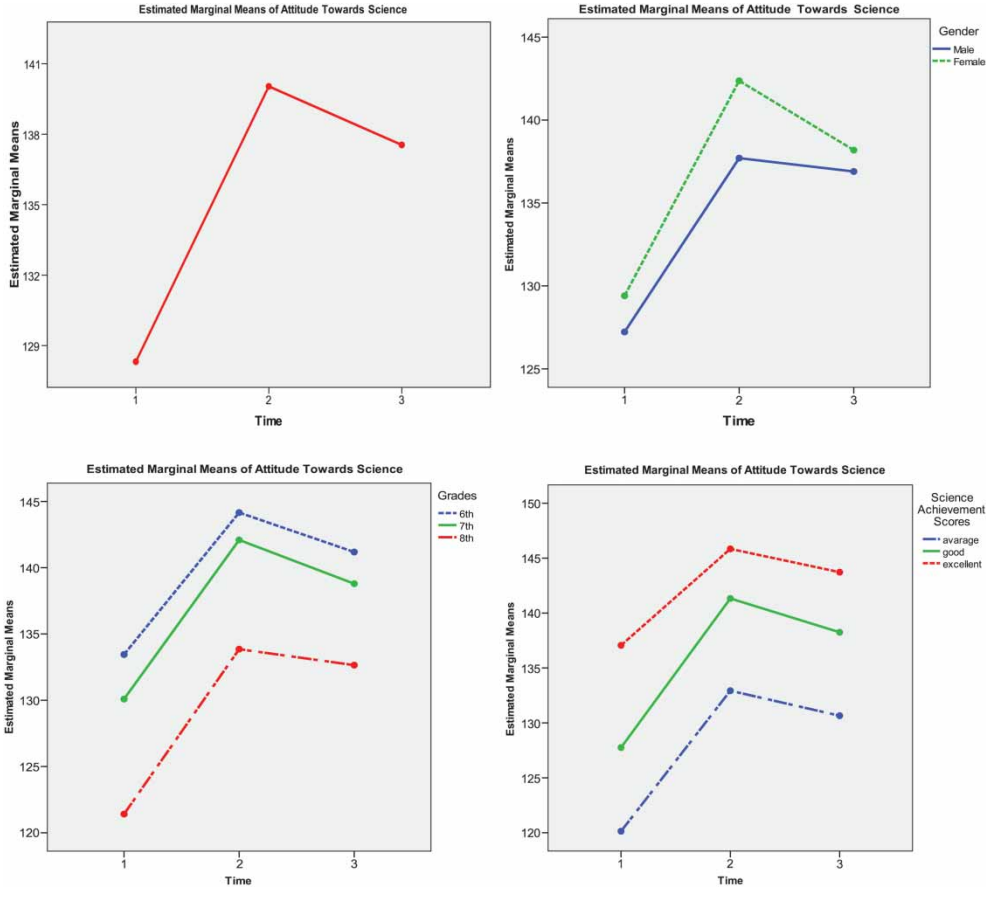

Figure 8. Estimated marginal means of attitude across the three time periods, for males and females, for students in different grade levels, and for students with different SALs

Holding up the positive attitudes is highly related to students' positive experience in their social context. For example, Jarvis and Pell's (2005) in-depth interviews with students revealed that the positive impact of a science centre on students' attitudes was undermined by their negative school experiences at a later time.

One particular advantage of the current study was that different constructs of attitudes towards science were measured and each construct was analysed separately. Previous studies have pointed out that the lack of clarity on attitudes towards science blurs the actual effect of science centres on students' attitudes (Barmby et al., 2008). Analysing different constructs of attitudes towards science separately revealed that while METU SC had a positive impact on students' attitudes related to learning science in school, self-concept in school science, science outside of the school, future participation in science, and importance of science, it did not have an impact on practical work in school science. On the other hand, the results related to the importance of science were distinguished from the others. Although the scores on the other constructs of the attitude scale decreased one week after visiting METU SC, the scores on the

importance of science kept increasing. We can generate some speculations about the possible reasons of this result. One reason might be that believing in the importance of something does not necessarily make people enthusiastic about participating in it. For example, many people value art but only a small number of people are enthusiastic about performing practical work in art. Another reason might be that students make a distinction between 'science' and 'school science'. It is possible to generate further speculations; however, these results need to be supported with different populations and science centres to understand whether this result is specific to the population and the setting of this study or is a general pattern.

In terms of gender differences on students' attitudes towards science, the literature is inconclusive. While some studies argued that boys' attitudes towards science are significantly higher than girls' (Breakwell & Beardsell, 1992; Catsambis, 1995; Francis & Greer, 1999; Reid & Skryabina, 2003; Simpson & Oliver, 1990; Weinburgh, 1995), others presented evidence on the opposite (Baker & Leary, 1995; Harwell, 2000). Still others showed that there was no gender difference in students' attitudes towards science (e.g. Çakır, Şenler, & Taşkın, 2007; Dhindsa & Chung, 2003; Greenfield, 1997; Scantlebury, Baker, Sugi, Yoshida, & Uysal, 2007). METU SC had a positive impact on both female and male students' attitudes towards science and this impact was equal for both groups. Girls started with more positive attitudes than boys. Even though both boys and girls increased their attitude scores on the post-test, girls showed more improvement than boys. This result is consistent with the findings of Jarvis and Pell (2005). In the study of Baker and Leary (1995), 40 girls reported that they liked learning about science in the interactive social context rather than participating in activities that isolated them (e.g. independent writing, reading or note-taking). Similar findings were obtained from the ROSE (Relevance of Science Education) project in which 40 countries (including Turkey) participated. As a result of this study, Jenkins and Pell (2006) reported that helping other people is more important for girls than for boys. High level of interactions and supports provided by the guides during students' explorations in METU SC might have created different effects on girls and boys. One week after the visit, both boys' and girls' attitudes towards science decreased. However, girls' attitudes declined more than boys'. This result is also consistent with the findings of Jarvis and Pell (2005). The sharp decline in girls' attitudes may be related to different factors affecting their attitude towards science in their social settings. The related literature particularly focused on the factors in school settings. For example, several studies have argued that girls' lack of hands-on experiences or limited social interactions in school science negatively affects their attitudes (Baker & Leary, 1995; Dawson, 2000; Greenfield, 1997; Shakeshaft, 1995).

Considering students' attitudes towards science with regard to grade levels, it can be seen that students' grade levels were inversely proportional with their attitudes towards science. This finding is consistent with the findings reported by Barmby et al. (2008), Bennett and Hogarth (2009), Çakır et al. (2007), Coughlan (2000), Francis and Greer (1999), George (2000, 2006), Greenfield (1997), Kelly (1986), Osborne et al. (2003), and Reid and Skryabina (2003), but opposite to the findings

of Breakwell and Beardsell (1992), and Hassan (2008). However, METU SC had a significant and equal impact on the attitudes of students in different grade levels. In terms of students' SALs, Mattern and Schau (2000) showed that SALs were directly proportional with students' attitudes towards science. The data collected during this study also supported this conclusion. However, METU SC had a significant and equal impact on the attitudes of students with different SALs.

Conclusion

Similar to the findings of many other studies (e.g. Jarvis & Pell, 2002, 2005; Rennie & McClafferty, 1995; Rix & McSorley, 1999), the results of this study also provided confirmatory evidence for the argument that science centres have a positive impact on students' attitudes towards science. Furthermore, this impact can be independent of gender, grade levels, or science achievements according to the results of the current study. Students' perception of science and science-related activities seems to depend on the environment in which science is presented because different environments show different aspects of science. One of the most important aims of teaching science in a school environment is to help students gain a broader view of science and develop their attitudes towards science accordingly. However, there are inherent limitations of school settings such as the inadequacy of infra-structures, low economic capacities, or the standards to be covered in a limited time period. Therefore, informal learning environments, especially science centres, provide opportunities to tide over some of these limitations. In the current study, the focus was on students' attitudes towards science, and the aim was to elaborate a science centre's contribution to students' attitudes towards science. However, further studies focusing on cognitive as well as affective variables are needed to describe the unique contributions of science centres on students' possible gains.

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