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Evaluation of Beliefs and Attitudes of High School Students towards Science and Mathematics Courses

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ABSTRACT

This study explored secondary school students' attitudes, beliefs and emotions towards mathematics and science in six high schools in Ankara, Turkey, in order to develop a framework for studying students' affective domain. Data were collected via a survey, which included both a 6-point Likert-type scale and open-ended questions. Data analysis aimed to uncover the relationships between gender, grade level and the affective domain. Results indicated that students had generally positive attitudes towards mathematics and science courses. Mathematics was the most favoured subject. Female students favoured biology courses more than male students; whereas male students stated that they liked physics courses more than female students. The main reasons for developing positive and negative attitudes, beliefs and emotions were being able to understand the subject and the teacher.

Key Words: Students' Attitudes; Students' Beliefs; Mathematics Education; Science Education.

INTRODUCTION

The most enjoyable course is physics because I believe that I really understand it and I succeed in it…I don't like to memorize and physics is not based on memorization. Physics and biology are the most interesting courses because most of the information that could be used in daily life is offered in these courses. I am worried about chemistry because I fear not understanding. It is hard to understand chemistry because we memorize things that we should understand (Didem).

As we can see from the above quotation by Didem (pseudonym), a grade 9 female student, there are different elements of one's affective tendencies towards a subject. They may include one's beliefs about a subject, such as Didem's belief about physics being not based on

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memorization, or one's emotions, such as Didem's fear of not understanding chemistry. Attitudes, on the other hand, show one's positive or negative feelings towards a subject, such as Didem's enjoyment of physics courses. Moreover, Didem shares her reasons for her affective tendencies towards different science courses in the above quotation. There may be many different influences on developing positive or negative attitudes, beliefs, emotions, or values towards a course. However, before discussing possible sources for students' positive and negative affective tendencies towards mathematics and science courses, we will discuss some of the results offered in the literature.

When we examined the studies related to students' affective domain in the field of education, two major variables were observed. First, students' attitudes, beliefs or emotions are subject to change as they progress in their education. Students' positive attitudes seem to decrease from elementary and middle school to secondary school (Heber, 1998; Hoffmann & Lehrke, 1986; Kanai & Norman, 1997; McLeod, 1992; National Science Foundation, 2003; Neathery, 1997; Reid & Skryabina, 2003; Wilkins & Ma, 2003). According to data published by the National Center for Education Statistics (NCES), students' attitudes towards mathematics and science were steady (U.S. Department of Education, n.d.a and n.d.b). This data has been periodically collected from representative samples of students as part of the National Assessment of Educational Progress (NAEP) for the United States. Therefore, the data is cross-age in nature. Fifty percent of the secondary education participants in the NCES study mentioned that they liked mathematics/science. However, fourth grade students displayed more positive attitudes towards mathematics and science than eighth and twelfth grade students (U.S. Department of Education, n.d.a and n.d.b).

The second topic related to attitude studies in the education field was gender difference. The studies concluded that male students developed more positive attitudes towards mathematics and science as compared to female students (Kanai & Norman, 1997; Martin et al., 2000; Mullis et al., 2000; National Science Foundation, 2003). Females showed less interest towards science classes than males, with the exception of biology (Hoffmann & Lehrke, 1986; Miller, Blessing & Schwartz, 2006; Telli, Rakici, & Cakiroglu, 2003). Miller, Blessing, and Schwartz (2006) indicated that females are more "people-oriented," and "girls tend to be more oriented to the human aspects of science (e.g., helping people, animals, or the earth) than to more abstract scientific principles, methods, and instruments" (p.376). The gender difference in attitudes toward science becomes especially evident for the physics classes, with females displaying more negative attitudes (Reid & Skryabina, 2003). Some probable reasons include the requirement of scientific thinking skills/meaningful learning approaches that males use more often and difficult laboratory experiments and environments that may be favoured by male students (Cavallo, Roman, & Potter, 2004; Todt & Händel, 1988).

Research Questions

It is apparent that there are many influences affecting students' affective domain. However, it is imperative to ask students to reflect and explain their reasons for their attitudes, beliefs, emotions or values and observe whether those reasons are similar to those found in the literature. With this aim in mind, this study analyzed Turkish secondary school (9^{th}, 10^{th}, and 11^{th} year) students' attitudes, beliefs and emotions towards mathematics and science classes. In two previous studies, we discussed students' positive and negative attitudes separately (Özgün-Koca & Şen, 2006; Şen & Özgün-Koca, 2005). The main aim of this article is to analyze and compare students' positive and negative attitudes concurrently. The specific research questions of this study were:

1. What are Turkish secondary school student attitudes, beliefs and emotions towards mathematics, physics, chemistry, and biology courses?
2. Are there any differences in students' attitudes, beliefs and emotions according to gender and years of schooling?
3. What kinds of reasons are provided by students for their positive and negative attitudes, beliefs and emotions towards mathematics, physics, chemistry and biology courses?

Conceptual Framework

We based our study for affective domain on DeBellis and Goldin's (1997, 2006) Tetrahedron Model. We believe that this is one of the well established frameworks in the area of research. In this model, beliefs, attitudes, emotional states and values/morals/ethics are displayed as vertices of a tetrahedron. A similar tetrahedron model of affective domain was used also by Hannula (2005). In their model, DeBellis and Goldin (2006) noted that four components interact with and influence each other: beliefs, attitudes, emotions and values. They define these components as follows:

> Emotions describe rapidly-changing states of feeling experienced consciously or occurring preconsciously or unconsciously during mathematical (or other) activity.
>
> Attitudes describe orientations or predispositions toward certain sets of emotional feelings (positive or negative) in particular (mathematical) contexts.
>
> Beliefs involve the attribution of some sort of external truth or validity to systems of propositions or other cognitive configurations.
>
> Values, including ethics and morals, refer to the deep, 'personal truths' or commitments cherished by individuals (p.135).

The notion of 'attitude' is a central concern in our study. Eagly and Chaiken (1993) define attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour" (p. 1). Eagly and Chaiken clearly highlight that "evaluating refers to all classes of evaluating responding…(such as) cognitive, affective, or behavioural" (p. 1). Attitude was defined by McLeod (1992) as the positive or negative degree of affect associated to a certain subject concerning mathematics education. In the literature, we see some studies that describe and discuss the affective domain as a whole, which includes beliefs, attitudes, and emotions. McLeod and Ortega (1993), in describing the affective domain, state that "beliefs, attitudes, and emotions are terms that reflect the range of feelings and moods that make up our affective responses to mathematics" (p. 22). DeBellis and Goldin (1997) argued that a fourth component – values (which includes morals and ethics) – should also be taken into consideration. Some examples include students' affective perspectives towards mathematics and science, such as beliefs ("mathematics or science is useful or I am good at mathematics or science"), attitudes ("I like or dislike mathematics or science"), emotions ("solving mathematics or science problems makes me happy") and values ("failing a mathematics or science class is normal").

As it can be observed from the DeBellis and Goldin's model, the affective domain has a complex structure. While emotions are not stable, attitudes, beliefs, and values are more stable. A person might develop his or her attitudes, beliefs and values over time as a result of experience and social interactions. This might explain why they are more stable. Emotions, on the other hand, even though not stable, might have both conscious and unconscious with mild or intense effects on one's affective domain. As DeBellis and Goldin (2006) explained, these four constructs interact dynamically; thus, one's intense emotions (such as fear) could influence attitudes (towards a problem during a problem-solving activity). Additionally, one's intense negative attitudes might cause anxiety during an activity.

These beliefs, attitudes, emotions, and values towards a subject may influence a person's actions. Hart (1989) and Kobella (1989) discuss the influences of the affective domain on a person's behaviour in regards to mathematics and science education. Hart (1989) stated that "a positive or negative attitude toward mathematics could be inferred from…one's behaviour in approaching or avoiding mathematics" (p. 39). Therefore, affective domain could simply be defined as a person's positive or negative affections (including beliefs, attitudes, emotions and values) toward a subject, which could have an influence on one's behaviour or actions regarding that subject. The results of the studies in mathematics and science education which focused on students' affective domain concluded that students' attitudes, beliefs or emotions formed at the beginning of their education may affect their whole educational experience. Students' attitudes, beliefs or emotions towards a subject or course might be related to their approach to the course, level of knowledge, achievement, willingness to learn, and interest (National Council of Teachers of Mathematics, 2000; National Research Council, 1996).

DeBellis and Goldin (2006) discussed that not only these four constructs have interactions among each other, but also there are external contextual factors and social and cultural conditions which influence people's affective systems. Therefore, one's interaction with peers, teachers, school administration, and family could have impacts on their affective domain. These interactions make the affective domain more complex and dynamic. DeBellis and Goldin argued that the beliefs, attitudes, emotional states and values of others might affect one's affective domain. In their model, beliefs of others, attitudes of others, emotional states of others, and values/morals/ethics of others are placed on the outside of a rectangular box which includes the tetrahedron. This indicates that, even though one's affective domain is self-contained and there are internal interactions happening among its four constructs, it is also possible for external interaction to influence the internal system. With this study, we aim to specify the external factors in greater detail and add possible internal factors to the DeBellis and Goldin's model.

METHODOLOGY

The study took place in six secondary schools in Ankara, Turkey. Four of the schools were regular public high schools, while two of them were Anatolian high schools. Regular public schools are open to all students and follow a national curriculum in the native language. Anatolian high schools are another type of Turkish public school that registers students after a very competitive national exam. Mathematics and science classes were offered under common general cultural classes at the ninth grade level. At this level, mathematics courses were five hours per week, while physics, chemistry, and biology courses were two hours per week. For the last two years of secondary education, students were required to choose their preferred area of study, such as science (as the students participating in this study did), social science, Turkish-mathematics (an area of study that focuses on mathematics and social science for future majors in fields such as business administration or law) and foreign language. At the tenth and eleventh grade level, mathematics and science classes were offered under subject area courses for students who chose science as their area of study. Mathematics courses were offered five hours per week for both the tenth and eleventh grade levels (with additional geometry classes two hours per week). At both levels, physics courses were offered four hours per week, and chemistry classes were offered three hours per week. Biology courses, on the other hand, were offered two hours per week at the tenth grade level and three hours per week at the eleventh grade level. All science courses had a separate two hours per week for set aside for laboratory work during the last two years of high school.

Participants

Participants in this study were chosen from the six different secondary schools mentioned above (n=608) by convenience sampling. As teacher educators, we had access to these public schools at the student teaching phase of our pre-service teachers' education. In our expert opinion and as a result of our observations in many other high schools, it could be concluded that these schools are a representative sample of public high schools in the capital city of Turkey. Forty-nine percent of the participants were male, and fifty-one percent were female. Thirty-six percent of the participants were ninth grade students, thirty-two percent were tenth grade students, and thirty-two percent were eleventh grade students.

Data Collection Methods and Analysis

Data were collected using a survey, which included both a 6-point Likert-type scale (1=Strongly Disagreed, 2= Disagreed, 3=Somewhat Disagreed, 4= Somewhat Agreed, 5= Agreed, and 6= Strongly Agreed) and open-ended questions. The survey was developed by the authors in consideration of similar instruments in the literature (Aşkar, 1986; Tapia & Marshia, 2004). Even though there are many valid instruments to measure affective domain effectively (McGinnis et al. 2002; Salta& Tzougraki, 2004), the attitudinal instrument that Aşkar (1986) developed in Turkish and DeBellis and Goldin's model were used as a basis for the Likert-type questions. The survey included a total of eleven items in Turkish, some of which were worded positively and some negatively. There were five questions targeting students' attitudes, 'I like mathematics,' or 'chemistry class has been always fun for me.' In addition, there were three questions designed to elicit students' beliefs, such as 'physics class can be applied to reallife,' or 'I have always understood the topics in biology class.' There were also three questions targeting students' emotions, such as, 'I am most afraid in mathematics class,' or, 'I get worried in physics class.' Each question included three stages. For instance, participants were asked to indicate how much they enjoyed mathematics, physics, chemistry and biology courses and to choose "1" if they did not enjoy the course or "6" if they enjoyed the course. Participants were also asked to rate a statement for mathematics, physics, chemistry and biology separately. At the second stage, students were asked to choose the course they enjoyed most. Lastly, participants were asked to explain why they enjoyed the chosen course the most. The open-ended questions were used to obtain students' points of views and motives for their attitudes, beliefs and emotions. Due to the qualitative nature of the open-ended part of each question and the large number of participants, only eleven questions were used in this study.

Since we used a valid and reliable survey in Turkish as a basis for the instrument used in this study, we anticipated that our instrument would have a good foundation. However, since we had a new format with open-ended questions, we asked a panel of experts to examine the survey to ensure the validity. Even though we only used 11 items in the survey to study students' affective domain, the qualitative component of each question made it possible for researchers to gain in-depth data. The survey was modified according to the suggestions of the panel of experts before it was administered. The reliability coefficient of the Likert-type questions in the survey was calculated using Cronbach's Alpha as 0.784, which shows a moderate to high level of reliability for the instrument. The Likert-type questions were analyzed by using chi-square statistics to determine possible statistically significant relationships between variables. An alpha level of .05 was used for all statistical tests.

Due to the nature of the qualitative data obtained from the open-ended questions, analysis of the data was based on categorizing in order to investigate the emerging themes throughout. Checklist matrices were created in order to analyze students' affective domain according to their gender and grade levels. According to Miles and Huberman (1994), "the basic principle is that the matrix includes several components of a single, coherent variable" (p.105). Therefore, several elements of the students' explanations for their attitudes, beliefs and emotions were analyzed more thoroughly. First, students' responses were analyzed for common codes to create patterns. Then common codes and patterns were tallied in the checklist matrices. Those tallies made it possible to calculate the percentages of the students sharing similar views. When a category was formed, it had to be evident in at least at three out of the six schools, and for more than two students in each school. Participants' quotes were selected when they were typical, reflective, or communicative.

Data triangulation, investigator triangulation with peer debriefing, and rival explanations were used to ensure the trustworthiness of this study. The collection of both quantitative and qualitative data empowered the validity of this study. Having two investigators coding and interpreting the data made it possible not only to create but also to check the codes and themes during the study. When analyzing students' explanations for their attitudes, we focused on rival explanations for both positive and negative attitudes. This made it possible to examine the different reasons which were used for positive and negative attitudes. Moreover, since the instrument was administered and the data were analyzed in Turkish, a disinterested peer translated the chosen students' quotations in order to further enhance the trustworthiness of the study.

FINDINGS

Students' Attitudes towards Mathematics and Science Courses

Looking at the averages calculated according to the 6-Point Likert-type scale, we observed from the high averages of the positive statements that students generally had positive attitudes towards science and mathematics courses. This result is in agreement with TIMSS-R 1999 results for Turkey reported in Özgün-Koca and Şen (2002). Mathematics comes forward as a course that is especially enjoyed (M = 4.7, SD = 1.6), and students would like to extend its allocation of hours (M = 4.2, SD = 1.9). Biology is found to be the course where the topics interested the students the most (M = 4.7, SD = 1.5). Physics followed biology as the second most interesting course (M = 4.1, SD = 1.7). Chemistry ranked at the bottom of the list of all positively stated items as the most liked course (M = 3.95, SD = 1.7). In terms of negative statements, it could be concluded that students had some negative attitudes towards biology and chemistry courses.

The mathematics course was ranked first for the three positively stated items. According to the participants, the mathematics course was the most fun, most liked course, and students would like an increase in hours per week for mathematics courses. However, the mathematics course was found to be not very interesting when the course content was considered. In the most interesting course category, the biology course ranked first. However, the findings were examined in further detail and it was observed that the positive and negative attitude statements differed according to gender and grade level.

The Influences of Gender and Grade Level on Students' Attitudes

Gender and attitude. Female and male students showed similar attitudes. Both groups shared their positive attitudes towards the mathematics course but found biology more interesting. More female students than male students mentioned that they found biology interesting, while more male students indicated they found physics courses interesting than female students. This pattern was also observed in the negatively stated items. More female students than male students mentioned that they were afraid and worried when it came to physics, and they neither wanted nor liked it. On the other hand, when compared to the number of female students, more male students shared the same feelings for biology courses.

The statement on liking the physics course was the only statement that received a significantly more positive tendency from the male students when compared to the female students [$\chi^2(5, N = 476) = 15.03$, $p = .010$, *Cramer's V* = 0.178]. Female students more frequently stated that they enjoyed the biology course, liked the chemistry courses and wanted to have more hours of chemistry and biology, than the male students. Again only the physics course has a statistically significant relationship among the negative statements when we focus on the gender differences. Female students tend to have negative attitudes towards the physics course in all statements which differed significantly from the male answers.

Grade level and attitude. Mathematics was again the most liked course by all grade levels. However, more students in the 10^{th} and 11^{th} grade levels mentioned that they would like to have more time allocated for the mathematics courses than did 9^{th} grade level students. Even though students in later grades would like to have more time for mathematics courses, fewer of them report thinking that it is fun, and fewer report liking it than their counterparts in the 9^{th} grade. Students' positive attitudes toward chemistry seem to decline as they move forward in their education. Students in later grades also shared that they liked the physics course more, found it more fun, and worried less about it. Similarly, students in their last year of high schooling mentioned that they found biology more interesting and would like to have had more time for this course.

Examining the relationship between the grade levels of the students and their finding the courses enjoyable, a statistically significant relationship [$\chi^2(10, N = 538) = 21.352$, $p = .019$, *Cramer's V* = 0.141] was found only for the physics course. The difference between 9^{th} and 10^{th} grade level students, which lead to the statistically significant relationship, indicated that the Grade 10 students found the physics course more enjoyable than the Grade 9 students. In terms of the relationship between grade levels and the negative attitudes of students towards the courses, a statistically significant relationship between the physics course and grade level was observed for being afraid of the course and students' being worried about the chemistry course.

Students' Rationales for their Attitudes, Beliefs or Emotions

In this section, we present the qualitative part of our data which attempts to explain the students' rationales for their affective domain. Here we will make use of DeBellis and Goldin model in interpreting our results and adapt it in the light of our results.

Being able to discuss the major reasons for students' attitudes, emotions or beliefs might help educators understand their students in a better way and perhaps help them more effectively. Students were also asked to explain the reasons for their positive or negative attitudes towards mathematics and science courses. Table 1 (Appendix B) and Table 2 (Appendix C) list the major common reasons for positive and negative attitudes respectively. These tables were created according to the checklist matrices generated during the data analysis. Students' responses to the positively and negatively stated open-ended questions are categorized according to the subject areas. The categories are listed in these tables in order; starting from the most common category. Different colours were assigned to different categories; for instance yellow was used for understanding category or orange was used for the teacher category. Despite having 608 participants, due to the design of the survey we had low percentages for the categories. Each question first asked the participants to rate the statement for different subjects separately. Secondly, participants were asked to choose the one subject for which they agree the most and explain their choice. At this point, it is problematic to assume that the total number of participants is 608. If divided evenly, we could assume that there would be approximately 150 participants choosing each of the four subjects to explain their strong attitudes, beliefs or emotions. However, as a result of the qualitative analysis, there were always responses that could not be coded in the main categories. There were also students who in response to a Likert-type question stated their favourite subject or the subject that they are most afraid of, but did not explain their choice. All of these points collectively explain why the percentages were as low as they were for the qualitative part of this study since we used 608 as our total.

In examining the colour-coded tables, we concluded that the reasons that the students provided for their positive attitudes were more varied than the reasons provided for their negative attitudes; therefore Table 1 is more colourful than Table 2. Even though finding a course fun or interesting (29%), the teacher factor (26%), or being able to understand (24%) were the major common reasons to develop positive attitudes towards a course, different reasons specific to the subjects were provided by students in addition to those major reasons (Table 1). While understanding came more into the play for the mathematics courses than the teacher factor, teacher factor was more mentioned for the physics courses as compared to understanding category. Being a difficult subject or not being able to understand the subject (49%) and the teacher factor (33%) were the main reasons provided by students for their negative attitudes regardless of the subject (Table 2). Therefore yellow and orange colours were dominant in this table. More detailed analysis of data displayed in Table 1 and Table 2 is presented below.

Understanding the subject. We noticed that in order for the students to find the courses enjoyable (13%) and like them (10%), they needed to understand the courses regardless of their grade level (see Table 1). Twenty-three percent of the students mentioned that they develop positive attitudes when they are able to understand the content of the courses. Some students expressed the following sentiments:

> (The most enjoyable course is) mathematics. The classes are always fun. I can generally answer the questions. A course that you can succeed and understand is always fun. (10, F, 10)[1]
>
> (The most enjoyable course is) physics. Because I understand physics very well. (10, F, 21)

Almost half of the participants stated that the topics being difficult and not understanding them were the major reason for students' negative attitudes towards courses (see Table 2):

> (Physics) is a little hard for me but when I can do it, it is enjoyable, I go crazy if I don't understand it. (10, F, 35)
>
> (Biology is the most disliked among all courses). Because it is the only course I do not understand. (9, M, 50)

[1] In student codes, the numbers in parentheses indicate grade (Grade 9:9; Grade 10:10; Grade 11:11); gender (Female: F; Male: M) and the student code respectively.

Being able to understand was detected as one of the most important factors affecting students' attitudes towards mathematics and science courses. The two statements of the survey, "I always understand the topics of the course" and "it is especially difficult for me to understand the topics of the course," were evaluated in order to examine the relationship between students' attitudes in general and their understanding the course content. Students reported that they understood the mathematics course the best (M = 4.6, SD = 1.5). It was followed by the biology course especially for the female students (M = 4.3, SD = 1.5). The physics (M = 4.2, SD = 1.6) and chemistry (M = 4.1, SD = 1.6) courses were ranked low among the courses that were easy to understand. Statistically significant relationships were observed upon the analysis of the statements related to understanding and the ones examining the positive and negative attitudes. Students expressed that they understood the courses which they enjoyed, liked, found interesting and wanted to have more hours per week. Thirty-five percent of the students stated that they understood the mathematics course; so they liked it, enjoyed it and found it enjoyable. It was the same for 15% of the students, who favoured biology. Nearly 15%-22% of the students mentioned that they feared chemistry and physics, and they became worried in those courses. They said it would have been better if these courses did not exist in the curriculum as they were too difficult to understand. The quantitative analysis of the statements related to understanding, and the qualitative analysis of students' responses to the open-ended questions were in agreement, which increases the reliability of this study. In order for students to develop positive attitudes towards mathematics and science courses, it was seen that they should primarily understand the course content regardless of the grade level.

Teacher factor. In order to have positive attitudes towards a course, especially for students to enjoy (15%) and like (11%) the courses, the "teacher" factor was the major reason for all courses (see Table 1). Twenty-six percent of the students discussed their teacher as a reason for them to develop positive attitudes towards a course. An eleventh grade male student mentioned that physics is his favourite course, "because I love my teacher very much." Liking the teacher was not enough for students to like a course. The methods that the teacher used in her or his instruction affected students' attitudes:

> (The most enjoyable course is) physics. Our teacher is very good and makes us love physics. S/he makes topics enjoyable while teaching them. (10, M, 16)
>
> (My favourite topics are) mathematics and biology. Because our teachers use different methods for us to comprehend the topic. (10, F, 47)

Similarly, the teacher was one of the major reasons for developing a negative attitude (see Table 2), especially for students not to like (11%), to be worried (11%) and afraid (8%) about the courses. One-third of the students mentioned their teachers when explaining why they did not like or were worried about a course. Disliking the teacher, her or his style, or the ways that the teacher treats students were among the reasons for negative attitudes towards the courses: "(In chemistry) our teacher is very sulky and s/he yells at us a lot" (9, M, 9).

Having fun or finding the subject interesting. When looking at the students' reasons for their positive and negative attitudes, another main category was having fun or getting bored in the class. Students mentioned that when they find the course fun, it becomes more interesting (8%), and they like (6%) it more.

> (The most enjoyable course is) biology. Because it is different, interesting and fun. (10, M, 14)
>
> I like the chemistry course the most because it is fun and I believe that it is useful for me. (9, M, 3)

Similarly, when the courses are not interesting for students, they do not want to take the course (7%) or they become worried: "The course that I like the least is biology. Because I do not like the biology topics [content] it is boring for me" (9, M, 48).

It was also observed that all courses became more interesting (7%) for students if they were linked to real life (see Table 1). Correspondingly, when a course was not related to real life, students noted that course as unwanted (2%). Moreover, the topics of living things and human beings made biology courses more interesting. Similarly, chemistry and physics became more interesting for students because of the experiments.

> (The most interesting course is) physics. It is interesting to learn scientifically about the events (like Impulse, pulleys etc.), which we come across in our daily life. (10, F, 4)
>
> (The most interesting course is) chemistry because it can be taught through experiments and examples from the real life. (9, F, 2)

The reasons for students' interest for increasing the hours per week were listed mainly as the courses being enjoyable, having inadequate course hours and being major subjects.

> Biology talks about living things. There are lots of living things in the world. I would like to know about all of them. (11, M, 16)
>
> (I would like the mathematics course to have more hours). Because you can't do the others without knowing this course. (11, F, 31)

Gender Influences. Even though the teacher factor and being able to understand or not were the main influences for both genders on the nature of their attitudes, male and female students stated different motives for different subjects. For instance, both male and female students mentioned that they like mathematics courses due to the numerical content. However, more male students than female students mentioned that they found mathematics courses fun, while more female students than male students brought up that they like problem solving activities in mathematics courses. Male students mentioned that they liked physics course due to laboratory activities. Female students found the content of physics courses difficult and uninteresting; therefore, they did not like it. Moreover, female students stated that the subject of life sciences in their biology course made them like the course and they found the content fun. In contrast, male students, when discussing their negative attitudes, stated that they found the contents of the biology course difficult and too verbal, i.e. not including numerical problems, formulas or algorithms. Female students who had positive attitudes towards the chemistry courses stated that they found the content interesting and linked to real life. When students were explaining their negative attitudes towards the chemistry course, female students mentioned that not being successful was causing problems for them and male students stated that not being able understand and finding the content difficult were the reasons for their negative attitudes.

DISCUSSION

When we synthesized the results of this study and other studies on students' attitudes in mathematics and science education, DeBellis and Goldin's Tetrahedron model was extended to include possible external and internal factors (see Appendix A, Figure 1). Internal factors could include but are not limited to: self confidence (Ma & Kishor, 1997; Zan, Brown, Evans, & Hannula, 2006); perceived usefulness of mathematics and science/relationships to real-life (Gilroy, 2002; Mitchell, 1999; Telese, 1997); intrinsic motivation such as achievement motivation (George, 2000); previous bad or good experiences (Olson, 1998); and finally personal interests. Self–confidence appeared in this study when students were talking about when they were able to understand a subject, they liked it and when they achieve it. Personal interests could be affected by the nature and content of different subjects. As Miller, Blessing and Schwartz, (2006) and this study indicated, gender could also play a role in developing interests for different subjects. For instance, females stated that they developed more positive attitudes than males in this study. Another reason for students' attitudes highlighted in the literature is the ability or inability to relate the content of mathematics and science courses to the students' daily lives. When students could not see the real-life connections, they seemed to develop negative attitudes towards mathematics and science (Gilroy, 2002; Mitchell, 1999; Telese, 1997).

External factors, on the other hand, might include (again not limited to) teacher influences (Başer & Yavuz, 2003; George, 2000; Todt, 1993a; Wilkins & Ma, 2003) and characteristics of the teaching and learning environment (Dawson, 2000; George, 2000; Mitchell, 1999; Olson, 1998; Osborne, Simon, & Collins, 2003; Reiss, 2004; Salta, & Tzougraki, 2004; Telese, 1997; Wilkins & Ma, 2003). This study confirmed that the teacher is one of the major factors influencing students' affective domain. Societal beliefs, as in the DeBellis and Goldin (1997, 2006) model, are part of the external factors influencing the affective domain (Andre, Whigham, Hendrickson, & Chambers, 1997; George, 2000; Gilroy, 2002; Olson, 1998; Schoenfeld, 1992; Todt, 1993b; Wilkins & Ma, 2003). Moreover, the attitudes of people in students' immediate environments—their family members and friends—have an impact on students' attitudes towards mathematics and science classes (Andre et al., 1997; Olson, 1998; Wilkins & Ma, 2003). Even though participants of this study did not bring up this influence in their affective domain, we included this factor as a result of evidence in the literature. Extrinsic motivation such as receiving good marks or reaching higher achievement levels is another factor that was included in our model as an example of an external factor (Olson, 1998).

Different components of the affective domain as well as internal and external factors might interact with each other (see Figure 1). For instance, this study showed that the strategies used by the teacher have an effect on students' attitudes. Gender related issues could be related to both internal and external factors. Students' personal interests could be influenced by gender, such as males liking physics more. Societal beliefs such as 'male students are expected to do well in mathematics and science courses but not female students' could affect students' affective domain. Moreover, the nature of the subject area could have affected students' affective domain; for example, male students favour the study of how physical things work, whereas female students want to learn more about living things.

We realized that one component-values-of this framework was not discussed in this study. The survey did not include any question targeting this component; therefore the results did not include any related discussion. However, we still wanted to keep the original conceptual framework as it is, but made additions as our results suggested.

CONCLUSION and SUGGESTIONS

The results showed that students generally had positive attitudes towards science and mathematics courses. Mathematics was the subject that was favoured the most by many male and female students. However, in previous studies, both international and Turkish students favoured science more than mathematics in cross-cultural studies (Mullis, et al., 2000; Özgün-Koca & Şen, 2002). This could be interpreted in different ways. First, in this study, science was not considered as a discipline but divided into subject areas. The total number of participants who favoured biology, physics, and chemistry is more than the number who favoured mathematics. That is why it could be understood that mathematics could be the most liked course when compared to individual science courses. Female students mainly found the biology courses more enjoyable, whereas the male students favoured physics more. Therefore, if a survey does not break science into separate disciplines, female students could think of biology first when the word 'science' is mentioned. Then they can respond positively. Secondly, mathematics is a basic subject area for the university entrance exam. The need to be successful in mathematics in order to do well on a university entrance exam might have positively influenced their affective domain.

This study showed that students' affective domain is a complex structure including beliefs, attitudes, emotions, and values (see Figure 1). But here values were not mentioned by students as much as other components of the affective domain. The influences of both external and internal factors other than societal beliefs were detected. When students' reasons were probed with open-ended questions not prompted with Likert-type questions, students chose to discuss their own views instead of others' views.

This study, agreeing with the studies in the literature, showed that being able to understand in a course or not is related to developing positive or negative attitudes towards it respectively. Students reported that they preferred understanding the content to memorizing it. This could be related to both external and internal factors (see Figure 1). Getting good grades could be seen as extrinsic motivation, an external factor. Being able to succeed in mathematics and science courses could help students improve their self-confidence and intrinsic motivation, an internal factor. Moreover, students' previous successes and failures were among the reasons affecting students' affective domain. Knowing students' previous achievements levels, teachers would not only understand students' possible existing attitudes but also serve them more effectively.

It was also found that the teacher factor was among the important reasons for positive and negative attitudes of students towards the courses. The importance of teachers' behaviours such as yelling in the class, which would decrease students' interest and motivation in these courses, was emphasized by the participants of this study. Thus, teacher influence and the teaching and learning environment were among the main external factors in the theoretical framework (see Figure 1). Therefore, teachers should create an inviting and stimulating learning environment for students and be a model by demonstrating positive behaviour in class.

Many studies have concluded that male students, generally, have more positive attitudes towards mathematics and science than do the female students. In this study, however, it was observed that the general tendency for both genders was the same. Female students also had positive attitudes towards mathematics and science courses. Apart from female students finding biology more enjoyable and male students favouring physics, female students, for instance, liked mathematics courses, wanted to do experiments in chemistry courses, and asked to have more hours of physics per week. In fact, this result indicates how the positive and negative attitudes towards the courses are more related to the content of the courses and how they are taught. Therefore, the question of "how" the topic is taught gains importance in addition to "what" is taught. The teacher factor, which was observed in the qualitative analysis of the data, should not be neglected in this respect. Thus, teacher education also comes out as an important issue which is part of the framework (see Figure 1). Helping pre-service teachers develop not only their content knowledge, but also their pedagogical and, more importantly, pedagogical content knowledge in their teacher education programs could very beneficial in this aspect. Teachers should also take students' attitudes into consideration and assess the affective aspects of the students. Then they could use and apply the results of their evaluations in their teaching.

In the analysis of the negative attitude statements, the statistically significant relationship between gender and attitudes towards the physics course should be considered. Female students tend to have more negative attitudes towards the physics course than the male students. In order to improve female students' attitudes in a positive way, an interdisciplinary approach could be applied to teaching physics by constructing bridges between mathematics and biology courses, which were favoured more by the female students (Hazari, Tai, & Sadler, 2007).

There are many studies in the literature that use quantitative methods to study students' attitudes. They look for possible reasons for students' attitudes by correlating different quantitative data. However, in this study we studied students' affective domain by using the combination of quantitative and qualitative methods. Likert-type questions were used to observe the nature of students' affective domain. However, the possible reasons for students' attitudes were not prompted through Likert-type questions such as 'I like mathematics class because I like the teacher.' Rather, those potential reasons emerged from the analysis of students' answers to the open-ended questions.

The design of this study gave us opportunities to compare not only different reasons for the directions of the attitudes, beliefs, and emotions (positive or negative), but also how the content and the nature of the subject area might have influenced students' affective domain. We asked students to discuss their reasons for selecting the course they like the best among mathematics and the different science courses. For example, we were able to study why some students like physics the most among those courses. These comparisons made it possible to observe the different effects of internal and external factors. Did the teacher of the physics class make a difference compared to the teachers in other courses? Or did being able to do well in the mathematics course make a difference?

We also aimed to observe the influences of gender differences in this complex structure. The existing research literature says that more female students like biology classes than do males. This combination of quantitative and qualitative methods made it possible to see that this result was confirmed by our study. Moreover, we studied the potential reasons for different genders developing different attitudes. For instance, our analysis revealed that the content of biology classes is a reason for the positive attitudes of female students and also a reason for the negative attitudes of male students. Teachers could reflect on the potential ways of making biology courses more appealing to male students; for instance in this age of technology, teachers can use examples from bio-engineering in class which could be an interesting topic for male students.

In this study we focused on not only one age group of students but on students at different high school grade levels. This enabled us to observe if there are any differences between different grades. Finally, the origin of this study makes it possible to observe potential cross-cultural differences. The researchers and teachers in other cultures with similar settings could reflect on the results of this present study as a starting point and make connections with their own situations.

Similar studies on students' attitudes that affect their education remarkably have great importance for recognizing and following students' dynamic affective behaviours in this rapidly changing world. Doing so cannot fail to have a positive effect on their education. On the other hand, failing to do so can have dire consequences.

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Appendix A

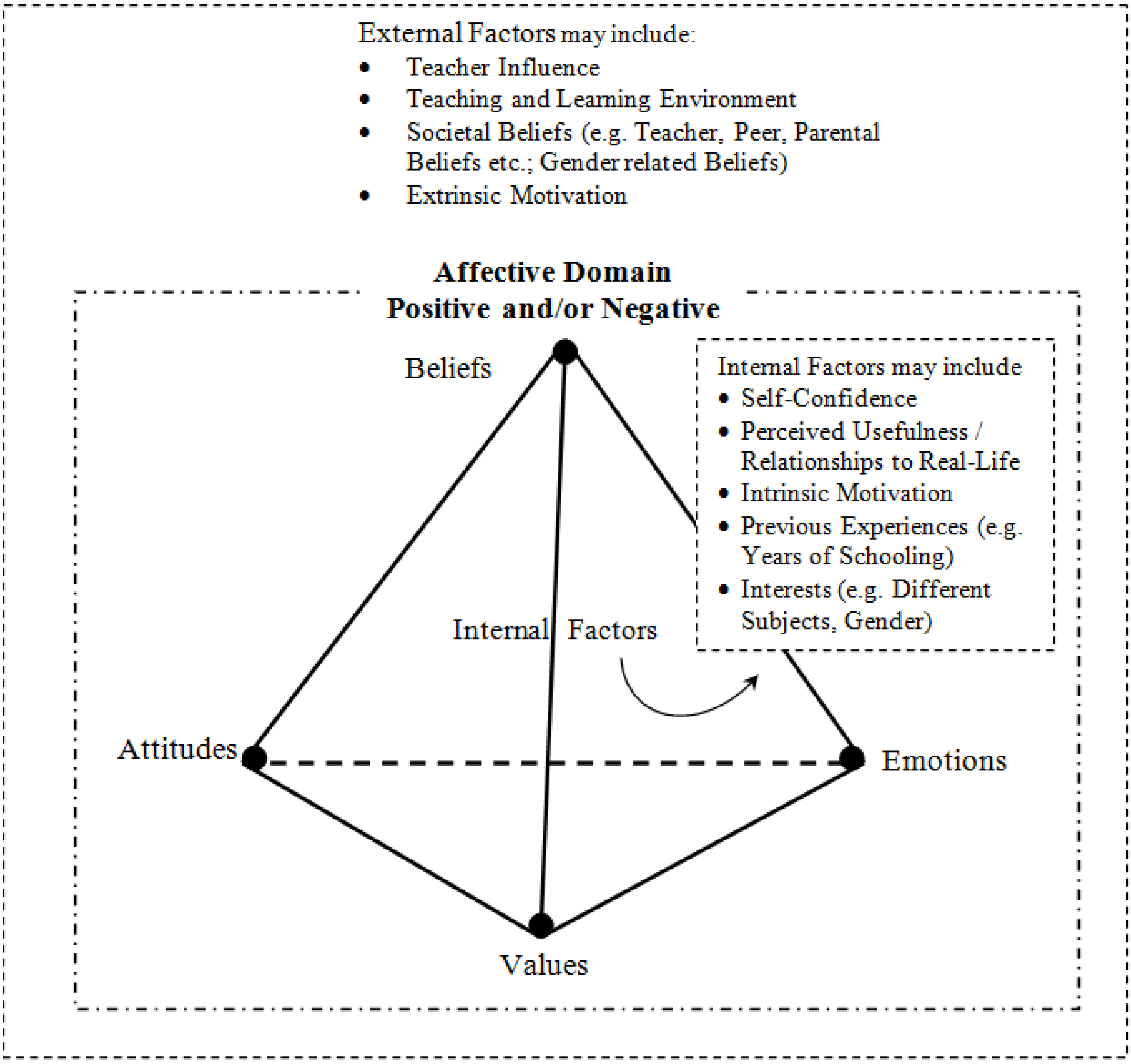

Figure 1. *Theoretical framework*

Appendix B

Table 1. *The Reasons for Positive Attitudes of Students towards Science and Mathematics Courses* (n=608)

Subject	Why "Enjoyable"?	Why "Interesting"?	Why "Liked"?	Why "Need for More Classes"?
Mathematics	1. Understand (7.2%)	There were not enough cases to create codes and categories for the subject of mathematics in this question.	1. Understand (5.9%)	1. Fun (5%)
	1. Teacher (7.2%)		2. Teacher (2.8%)	2. Fundamental Subject (3.2%)
	2. Numerical/ Quantitative (5.6%)		2. Fun (2.8%)	3. University Entrance Exam (1.9%)
	3. Problem Solving (4.4%)		3. Problem Solving (2.3%)	4. Do Not Understand the Subject (1%)
Physics	1. Teacher (3.5%)	1. Related to the Real-Life (3.6%)	1. Teacher (3.5%)	1. Not Enough Time (3.3%)
	2. Understand (1.2%)	2. Interesting Subject (3.3%)	2. Understand (3%)	2. Fun (1.6%)
		3. Experiment (1.2%)		
Chemistry	1. Understand (2.5%)	1. Interesting Subject (4.3%)	1. Interesting Subject (2.3%)	1. Fun (1.5%)
	2. Teacher (2.2%)	2. Related to the Real-Life (1.7%)	2. Teacher (2.2%)	2. Not Enough Time (1.3%)
	3. Interesting Subject (1%)		3. Fun (1%)	
Biology	1. Interesting Subject (4.5%)	1. Life Sciences (8.7%)	1. Teacher (2.2%)	1. Not Enough Time (2.8%)
	2. Teacher (2.5%)	2. Human Body (5.9%)	2. Life Sciences (1.5%)	2. Fun (2%)
	3. Understand (1.7%)	3. Nature (7.2%)	3. Understand (1.2%)	
		3. Related to the Real-Life (1.7%)		

Appendix C

Table 2. *The Reasons for Negative Attitudes of Students Towards Science and Mathematics Courses* (n=608)

Subject	Why "Afraid"?	Why "Worried"?	Why "Unwanted"?	Why "not Liked?"
Mathematics	1. Not Understanding /Finding it Difficult (5.8%)	1. Not Understanding /Finding it Difficult (3.5%)	1. Not Understanding /Finding it Difficult (3.2%)	1. Not Understanding /Finding it Difficult (3.2%)
	2. Teacher (1%)	2. Teacher (2.2%)		
Physics	1. Not Understanding /Finding it Difficult (9.2%)	1. Not Understanding /Finding it Difficult (3.3%)	1. Uninteresting Subject (1.9%)	1. Teacher (4.5%)
	2. Teacher (4.3%)	2. Teacher (2.5%)	2. Not Used in Real life (1%)	2. Uninteresting Subject (1.9%)
	3. Not Successful (1.9%)			3. Not Understanding /Finding it Difficult (1.5%)
Chemistry	1. Not Understanding /Finding it Difficult (6.9%)	1. Teacher (5.3%)	1. Not Understanding /Finding it Difficult (2.5%)	1. Teacher (4.8%)
	2. Teacher (3.2%)	2. Not Understanding /Finding it Difficult (4.5%)	2. Uninteresting Subject (2%) 3. Teacher (1.6%)	2. Not Understanding /Finding it Difficult (2.6%)
	3. Not Successful (1.2%)	3. Uninteresting Subject (1%)	4. Not Used in Real-life (1.3%)	3. No Background (1%)
Biology	1. Memorization (5.1%)	1. Memorization (3%)	1. Uninteresting Subject (3.0%)	1. Memorization (2.6%)
	2. Not Understanding /Finding it Difficult (2.5%)	2. Teacher (1.2%)	2. Teacher (1.3%)	2. Teacher (2%)
		3. Verbal/Wordy Qualitative (1%)	2. Memorization (1.3%)	3. Not Understanding /Finding it Difficult (1.3%)