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Factors Impacting Turkish Students' Attitudes towards Science and Their Academic Performance in Science

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ABSTRACT

This case study investigated the factors that impact Turkish high school students' attitudes towards science and their academic performance in science. The participants were 273 high school students representing students with diverse academic achievements and socioeconomic backgrounds. The results show that students cited their lack of motivation, socialization cost, poor teaching quality, intensity of content coverage and limited background knowledge as the source of their negative attitudes towards science and their low academic performance in science. The majority of participants cited securing their parents' and teachers' appreciation and self-appraisal as the main motivators for the time and effort that they invested into studying science. The discussion focuses on the importance of classroom discourse and teaching strategies for addressing students' low interest and performance in science.

Keywords: Attitudes; Science; High School Students.

INTRODUCTION

Science educators have invested significant efforts into studying students' attitudes towards science in recent years (Cakmakci, Sevindik, & Pektas, 2011; Jenkins & Nelson, 2005; Koballa & Glynn, 2007; Osborne & Collins, 2001; Reiss, 2004). This increasing interest in studying students' attitudes towards science is based on the assumption that there is some level of positive correlation between students' positive attitudes towards science and their achievement in science (Koballa & Glynn, 2007; Laforgia, 1988; Shrigley, Koballa & Simpson, 1988), willingness to take advanced science courses and desire to pursue science related careers post secondary education (Baker, 1985; Butler, 1999; Hidi, Renninger, & Krapp, 2004; Osborne & Collins, 2001).

These conclusions have been reached primarily based on the assumptions of the theory of reasoned action (Ajzen & Fishbein, 1980). According to the theory of reasoned action,

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attitudes predict the behavior that the individual will perform. Shrigley et al (1988) conducted a review of attitude studies in science education and concluded that, "the correlational consistency between attitude and behavior is high enough to indicate that casual forces exist between attitude and behavior" (p. 667). This conclusion suggests that students' attitudes towards science have a determining impact on how well they may perform in science courses or their desires to seek advanced educational opportunities in science (Koballa & Glynn, 2007; Osborne & Collins, 2001). In spite of their potential impact on students' learning of science, there has been limited interest among science educators to explore the reasons for students' attitudes towards science (Osborne & Collins, 2001). This is the case because science educators for long focused on "what students should know about science?" and paid limited attention to the ways in which we may be able to engage all students in meaningful science learning (Millar & Osborne, 1998).

As science educators move away from understanding learning solely through cognitive processes to understanding learning through the lenses of participation in a community (Lave & Wenger, 1991), socialization (Wentzel, 1999) and identity development (Roth & Tobin, 2007), designing studies that look at students' attitudes towards science learning, scientists and science careers becomes crucial (Cakmakci et al., 2011; Fensham, 2007; Koballa & Glynn, 2007). Research on students' attitudes towards science can address multiple concerns related to students' participation and achievement in science. First, it has the potential to shed light on equity issues in science learning (Baker, 1985; Baker & Leary, 1995; Butler, 1999). Second, it addresses students' voices in curriculum development (Jenkins, 2006; Logan & Skamp, 2008; Osborne & Collins, 2001; Schreiner, 2006). Third, it has the potential to shed light on the issues related to students' achievement in science (Koballa & Glynn, 2007). Finally, it addresses students' participation in STEM related careers in science (Baker, 1985; Baker & Leary, 1995; Butler, 1999; Kahveci, Southerland, & Gilmer, 2008).

As a result of this awareness about the importance of students' attitudes towards science, educators across the globe have conducted research on students' attitudes towards science. Several educators have investigated the attitudes of students in Europe (Osborne & Collins, 2001; Tymms, Bolden, & Merrell, 2008), the United States (Butler, 1999; Crawley & Koballa, 1992; Koballa & Glynn, 2007) and few other countries (Baram-Tsabari & Yarden, 2005; Lyons, 2006). Turkey is no exception to this increasing interest in studying students' attitudes towards science. Several studies have looked at Turkish students' attitudes towards science (e.g. Altinok & Un-Acikgoz, 2006; Cakmakci et al., 2011; Pehlivan & Koseoglu, 2010). However, the existing studies on Turkish students' attitudes towards science have some limitations. First, the majority of these studies focus on elementary students' attitudes towards science. Second, these studies focus only on a limited aspect of students' attitudes. For instance, Pehlivan and Koseoglu (2010) focused only on students' attitudes towards biology, Kaya and Geban (2011) looked at students' attitudes towards chemistry, Pehlivan and Koseoglu (2010) investigated the attitudes of high achieving students from a science and math magnet school (i.e. Ankara Fen Lisesi). Finally, most of these studies used a Likert-scale instrument to elicit students' attitudes towards science. Although the results of these studies provide invaluable insights into students' interest in science, they have limitations in terms of helping us to understand factors beyond instruction that may have a bearing on students' attitudes towards science.

The purpose of this study, therefore, was to explore factors that impact Turkish high school students' attitudes towards science, their academic performance in science and the relationship between the two through an in-depth analysis of students' responses to an open-ended questionnaire. More precisely, we explored answers to the following question: What are the underlying factors impacting Turkish high school students' attitudes towards science, science learning, science careers and achievement in science?

a) Review Of Literature On Students' Attitudes In Science

Science educators have studied students' attitudes towards science through multiple perspectives and in different contexts (e.g. high school and college) (Osborne, Simon, & Collins, 2003). Some scholars have looked at the difference between male and female students' attitudes towards science, some have looked at the influence of instruction on students' attitudes towards science (Altinok & Un-Acikgoz, 2006; Cavallo & Laubach, 2001; Kaya & Geban, 2011) and some have looked at the impact of curriculum on students' attitudes towards science (Lyons, 2006; Millar & Osborne, 1998; Osborne & Collins, 2001).

Studies exploring the relationship between curriculum and classroom instruction and students' attitudes towards science have established a positive relationship between the form of curriculum and instruction used in the classroom and the type of attitudes held by students. Gardner (1975) compared the influence of curriculum and teachers on students' attitudes towards science in a meta-analysis study. He concluded that, "what the teacher says and does in the classroom may override any effects produced by new textbooks, experiments or films" (p. 35). Cavallo and Laubach (2001) looked at the impact of instruction on high school students' attitudes towards science by analyzing their enrollment decisions in elective science courses. Cavallo and Laubach (2001) compared the attitudes of two groups of students who were taught by two different instructional methods: high pragmatic/high inquiry methods and low pragmatic/low inquiry methods. The results show that students who were enrolled in high inquiry classrooms developed more positive attitudes towards science than those who were enrolled in low inquiry classrooms. Moreover, they found that significantly more females in high inquiry classrooms showed commitment to taking advance science courses than the females who were enrolled in low-inquiry classrooms. In their conclusion, the authors state that the learning cycle model of teaching (high inquiry) leads to positive attitudes towards science among students and enhances students' persistence in science learning.

Osborne and Collins (2001) looked at students' attitudes towards science through a qualitative study. The results of their study show that both girls and boys cited chemistry and physics as the two most difficult science subjects, as they were irrelevant to their everyday lives. More interestingly, the same study revealed that students not only made negative comments about learning these two science subjects, but also they did not aspire to careers associated with physics or chemistry. These findings suggest that teachers need not only to acquire knowledge of subject matter and pedagogy to teach chemistry and physics, but also to acquire knowledge and skills to bring about conceptual change in students' attitudes towards chemistry and physics and the careers that are associated with physics and chemistry (Osborne & Collins, 2001). Such knowledge and skills are crucial to equitable science instruction and ensuring the participation of all students in science.

Baker and Leary (1995) interviewed forty female students in an effort to determine factors influencing their attitudes towards science. They looked at these female students' feelings about science and science careers by closely examining the influence of peer and parental support and science instruction on their attitudes. Regarding instruction, female students reportedly liked socially interactive science classrooms more than science classrooms that promoted independent learning. Baker and Leary (1995) also found that female students chose science careers either because of their desire to help or their affective experiences with a close family member or a friend (e.g. wanting to help a family member who has cancer). These findings blame girls' poor performance in science on the nature of school science curricula and the modes of instruction employed by the teachers of science, instead of students' perceived low self-efficacy to achieve in science. The argument holds that because the science curriculum emphasizes the knowledge and experiences of males and ignores those of females, the science curriculum marginalizes girls in school science courses, resulting in low achievement of girls in science (e.g. see Barton, 1998; Brickhouse, 2001; Stake, 2006).

The results of the studies reported in this review of literature point out that the form of instruction used and the nature of curriculum used are two important factors influencing students' attitudes towards science. However, additional factors may also have a bearing on the attitudes that students hold towards science. In an attempt to contribute to the existing research on students' attitudes towards science, we designed this study to understand factors impacting Turkish high school students' attitudes towards science. However, unlike existing studies, we attempt to understand factors that may have a bearing on the attitudes that the students hold towards science learning, their achievement in science, and their interest in pursuing advanced learning opportunities in science and science related careers following their secondary education through an open-ended questionnaire. An open-ended questionnaire designed based on a thorough review of literature on students' attitudes may provide a better picture of the diverse factors that may have a bearing on students' attitudes towards science. Understanding these factors can help curriculum developers, policymakers and teachers to address students' learning needs in an effective manner.

b) Studies Focusing on Turkish Students' Attitudes towards Science

Several studies have investigated Turkish students' attitudes in science; however, the majority of these studies focus on elementary students' attitudes towards science. While some of these studies focus on the impact of specific instructional interventions on students' attitudes towards science (Altinok & Un-Acikgoz, 2006; Kaya & Geban, 2011), others investigated their interest in science careers.

Altinok and Un-Acikgoz (2006) conducted a study to investigate the effects of cooperative and individual concept mapping and traditional teaching methods on 122 fifth grade students' attitudes toward science. One of the experimental groups was instructed through cooperative concept mapping, and the other one was instructed with individual concept mapping. The results of their analyses show that there is a significant difference between the attitude scores of the students in the cooperative concept mapping group and those of the students in the individual concept mapping group, with students in the cooperative concept mapping group showing more positive attitudes towards science than their counterparts. The researchers concluded that when students learn science through cooperative learning methods, they develop positive attitudes towards the learning of science. They argue that because cooperative learning methods promote social interaction among students and encourage them to learn science in a "threat free" environment, students enjoy learning science and show further interest in science. Kaya and Geban (2011) conducted a study with 11^{th} grade Turkish high school students and found that 11^{th} grade students who were taught by conceptual change-based instruction accompanied with demonstrations developed more positive attitudes toward chemistry than those taught with traditional instructional methods. Although these interpretations are informative, they do not help us to understand the factors beyond instruction that may have a bearing on the attitudes that students hold towards science.

In a similar study, Pehlivan and Koseoglu (2010) investigated high school students' attitudes towards biology and their academic self-concept in a biology course. The results of their analysis revealed a significant difference between male and female students in terms of both their attitudes toward the biology course and their academic self-concept, with female participants scoring higher than male participants. Furthermore, their analysis documented that 9th grade students held more positive attitudes towards biology than 10^{th} grade students, and 10^{th} grade students held more positive attitudes towards biology than their peers in the 11th grade.

In terms of the differences among the participants related to their academic self-concept, the analysis revealed that as the students moved up through the 9^{th} grade to the 12^{th} grade, they felt less competent in biology. For instance, when they compared the academic self-concept of the 9^{th} and 12^{th} graders, 9^{th} graders felt more competent in biology than their peers in the 12^{th} grade. Similarly, when they compared the self-concept of 11^{th} graders with those of 12^{th} graders, the students in the 11^{th} grade felt more competent in biology than their peers in the 12^{th} grade. Another interesting result of this study was that achievement level had no effect on students' attitudes toward the biology course, while it had an important effect on students' academic self-concept. The students who perceived themselves as successful in biology expressed a more positive self-concept towards achieving in biology than those who considered themselves less successful in biology. The researchers suggest that teachers of biology should use active teaching strategies and design instruction based on students' interests and real life experiences to help their students develop positive attitudes toward biology and feel more competent about achieving in biology. Although this study makes such recommendations, the results of this study are limited in that the participants come from a school that selects the best and brightest students in Turkey. Similarly, the teachers who teach at schools similar to Ankara Science School are better prepared both in terms of science content and pedagogy. Therefore, these results should be read with caution.

Tepe (1999) conducted a study that looked at the correlation between high school students' attitudes towards science and their achievements in science. The results of her study reveal that positive attitudes towards science account for 38 percent of variance in students' achievement in science.

While previous studies have provided invaluable information that can be used to develop responsive instruction that holds potential to bring about improvements in students' attitudes towards science, science learning and science careers, they have certain limitations, as well. For instance, most of the attitudinal studies conducted in Turkey have used a quantitative instrument to measure students' attitudes towards science, science learning and science related careers. These instruments may be able to capture students' attitudes towards science; they cannot elicit information about the underlying reasons for the attitudes that the students hold towards science, science learning and science careers. For instance, none of the reported studies explored why the students hold a positive or negative attitude towards science, science learning and science careers in-depth. The purpose of this study was to overcome the limitations of these previous studies by exploring factors that influence students' attitudes towards science learning, science careers and their achievement in science through an open-ended questionnaire. More specifically, we were interested in exploring answers to the following question:

What are the underlying factors impacting Turkish high school students' attitudes towards science, science learning, science careers and achievement in science?

METHODOLOGY

This study was conducted through a qualitative case study methodology (Merriam, 1998). Merriam (1998) defines case study as an in-depth investigation of an individual, group or an event with the purpose of uncovering the underlying causes of a problem observed with the individual or the group. Case studies are very useful in educational research, because most educational phenomena cannot be easily understood by establishing casual relationships between two numbers (Merriam, 1998). Case study methodology can be very instrumental in gaining an in-depth understanding of the important issues such as determining the factors that impact students' attitudes towards science learning and those that impact their failures and successes in science. Case studies are useful not only because they allow in-depth analysis of an issue, but also because they allow for generating hypotheses that may be critical to addressing an educational problem as important as students' negative attitudes towards science or underperformance of some students in science courses.

a) Setting and Participants

This study took place in a public high school in Turkey. The public high school is home to a diverse student population located in a middle class neighborhood in the western part of Turkey. This school was chosen because of its diverse student population (in terms of S.E.S) and ease of access to the participants. The school serves 1800 students, and there are 80 teachers in the school. The sample consists of 273 students; 135 females, 138 males, 95 9th graders, 80 10^{th}, and 96 11^{th} graders. In terms of participants' parents' level of education, 2.5% had a masters or PhD degree, 20.8% had a Bachelors degree, 36.4% had a high school degree, 38.5% had a middle school or elementary school degree, and 1.8% had no formal education. This diversity in parents' education levels gave us a greater chance to capture multiple factors that had a bearing on students' attitudes towards science.

b) Data Collection and Analysis

The participants completed an open-ended questionnaire (see Appendix A) that prompts students to answer a set of questions and then challenges them to justify the reasons supporting the answers that they provided. There are five main questions and 2-3 follow up questions for each main question on the questionnaire. The open-ended questionnaire was designed based on some pre-determined themes (drawn from the literature on students' attitudes) that focused on reasons that may support or hinder students' success in science and determine the direction of their attitudes towards science learning and science careers. Students were first challenged to elaborate on the perceived advantages and disadvantages of receiving a good grade in science, studying hard for science, pursuing science careers and advanced learning opportunities in science. Then they were asked to elaborate on factors that they thought made achieving in science easier or harder for them, factors that made it easier or harder for them to study for science and factors that made it easier or harder for them to pursue advanced educational opportunities in science or a science career. Additionally, we asked the participants few demographic questions. The demographic questions focused on participant's gender, parents' educational level, and grades in science and in school in general. The participants completed the questionnaire in one hour.

After the participants completed the questionnaire, the results were collected and later duplicated. The two authors independently read students' responses to each question, coded data and developed a set of themes that appeared to be important in understanding students' attitudes towards science and their under/over performance in science along with the underlying reasons. After each author independently read the students' responses, they compared their analyses and came to a consensus about the important themes that emerged from students' responses for each question. These themes were further validated through a second reading of the raw data. These themes and the frequency of their occurrences were recorded in tables and later transformed into figures shown in the findings section. After these initial themes were determined, the two authors evaluated students' responses table by table and considered their implications for curriculum, teaching and learning. The authors then developed a set of assertions based on students' responses to understand the factors impacting students' attitudes towards science and those that influence their academic performance in science.

c) Limitations

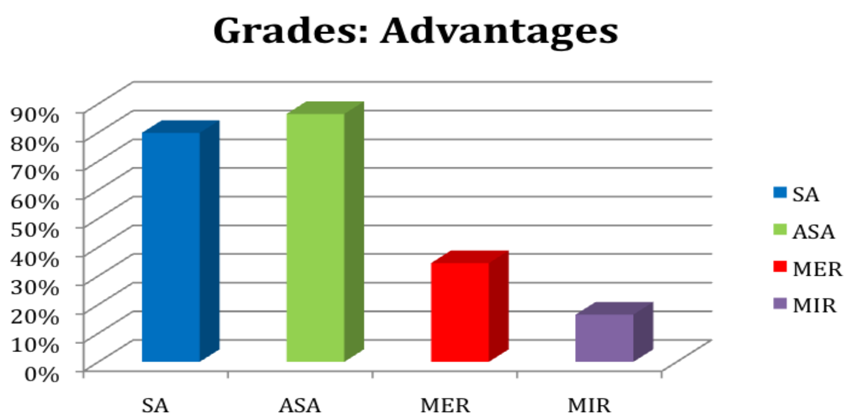
Like any other study, there are certain limitations to the findings reported and the conclusions drawn from the findings. First, the number of participants (n=273) places limitations on the findings we report in this study. Second, the culture of the school may have a level of influence on the responses that we received from the participants. Third, students may have interpreted the word "science" in different ways. Future studies can address these limitations by asking the students to indicate what they understand from the word science before they explore their attitudes towards science. Finally, we believe interview data could have provided unique contributions to our understanding of students' attitudes towards science and the perceived factors that may have had a bearing on their attitudes towards and achievement in science.

FINDINGS

The findings are organized in the following order. First, we present findings related to advantages and disadvantages that the students associate with receiving high grades in science. Second, we present findings related to students' perceptions of what makes receiving a high grade in science easy or difficult. Third, we present findings related to the perceived advantages and disadvantages of studying hard in science along with factors that make it easy or difficult for students to study hard for science. Then, we present findings related to perceived advantages and disadvantages of pursuing advanced learning opportunities in science. Finally, we present findings related to students' interest in pursuing a science-related career.

a) Advantages of Receiving High Grades in Science

When we asked the participants to share their views with us about the advantages and disadvantages of receiving high grades in science, they pointed out several advantages and disadvantages. In terms of its advantages, students viewed grades as a measure of who they are in terms of academic success (i.e. self-efficacy) (n= 218), as a tool to secure appreciation of or to avoid disappointment of significant authorities in their lives such as their parents and teachers (n=236), as a vehicle to attain a respected social and economical position in the long run (n=82), and to receive immediate rewards such as "free computer time"(n=12). Only 45 participants reported "increasing further interest in science" as a benefit of receiving high grades in science (see details in Figure 1).

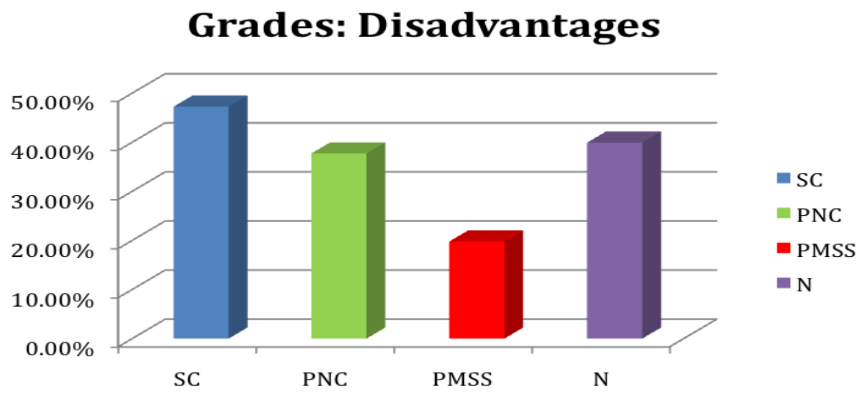


SA: Self appraisal,
ASA: Appreciation of significant authorities,
MER: Motivation for external rewards,
MIR: Motivation for internal rewards.

Figure 1. *Perceived Advantages of Receiving High Grades in Science*

b) Disadvantages of Receiving High Grades in Science

When we asked the participants to report on what they considered to be the disadvantages of receiving high grades, they provided such reasons as "requiring substantive effort and time commitment" (n=129), relying on a high grade and not studying for the subsequent test (n=37), being subject to peer jealousy (n=12), possibility of peers asking for extra help (n=54) and pressure to maintain their social and academic status (n=54). Only 109 students said, "there are not any disadvantages of receiving high grades in science"(see details in Figure 2).



SC: Socialization cost,
PNC: Perceived negative consequences,
PMSS: Pressure to maintain social status,
N: Nothing.

Figure 2. *Perceived Disadvantages of Receiving High Grades in Science*

When we asked the participants to tell us how likely they are to study hard for receiving a high grade in science after evaluating the advantages and disadvantages they reported, 30% percent said they are likely to study harder than they do now, and 68% percent reported that there will not be any changes in their study habits; about 2% did not respond to this question.

c) Factors that Make Receiving a High Grade in Science Easy

Another question that we wanted to answer was, "What does it take to receive a high grade in science?" from students' perspective. The majority of the participants (n=127) believed it took substantial effort, time commitment and practice with problem solving to receive a high grade in science. Almost half of the participants (n=94) stated, "the effectiveness of teacher" as a factor that can make receiving a high grade in science easier, 47 students believed the difficulty level of the test would make receiving a high grade easier in science, 41 participants cited having sufficient mathematical knowledge, 38 participants cited having a conducive learning environment at home, 51 students cited having interest in the lesson, 73 students cited understanding the teacher, and 98 students cited knowing how to study and how to take notes in the classroom as a factor that could make receiving a high grade in science easier. Only 28 students believed they could get a high grade in science if they asked questions when they did not understand the topic in class. See Figure 3 for details.

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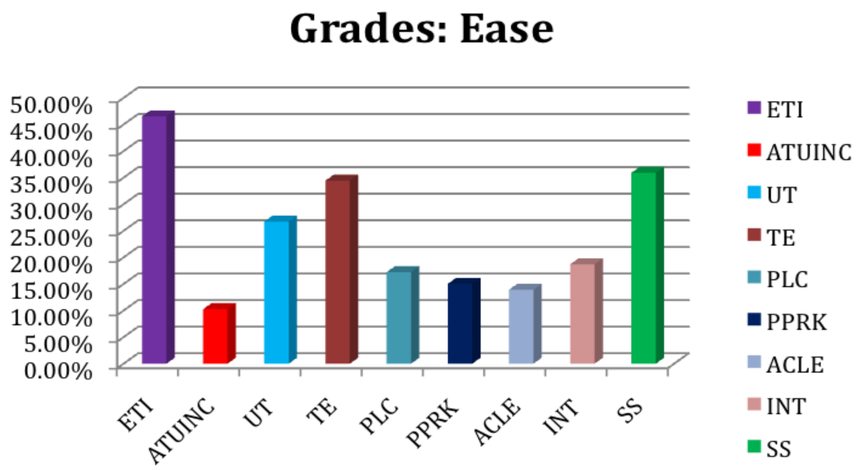
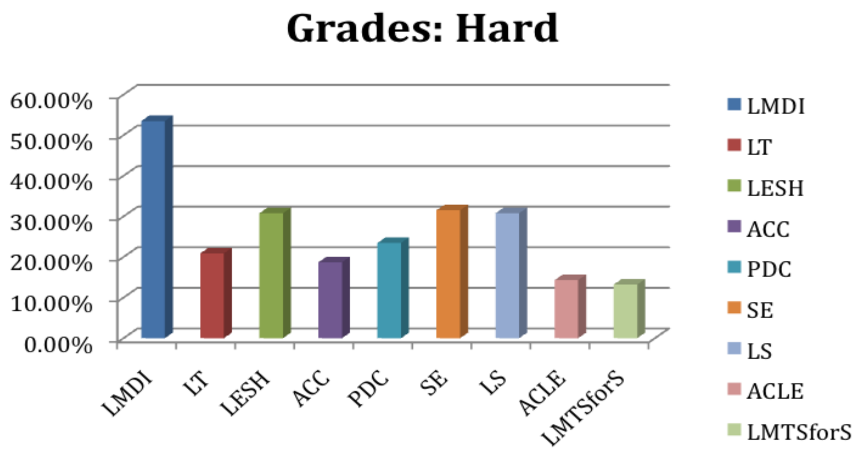


ETI: Effort and time invested, ATUINC: Asking teachers questions to understand in class, UT: Understanding the teacher, TE: Teacher effectiveness, PLC: Perceived level of challenge on test questions, PPRK: Perceived pre-requisite knowledge, ACLE: Access to a conducive learning environment, INT: Interest, SS: Study strategies.

Figure 3. *Perceived Factors that Makes Receiving a High Grade in Science Easy*

d) Factors that Make Receiving a High Grade in Science Hard

We also asked the participants to indicate the factors that they thought would make it challenging for them to receive a high grade in science. The results show that the majority of participants **(**n=146**)** cited lack of motivation to learn through classroom instruction, 57 participants cited lack of time to study for the tests, 84 students cited lack of established study habits, 36 students cited lack of motivation for the subject (e.g. I do not like science), 51 participants cited the amount of content for which they needed to study, 86 participants cited their lack of confidence in their ability to pass the course, 64 cited the perceived difficulty of the test content and 39 the availability of a conducive learning environment as factors that they considered would make receiving a high grade in science difficult (see details in Figure 4).

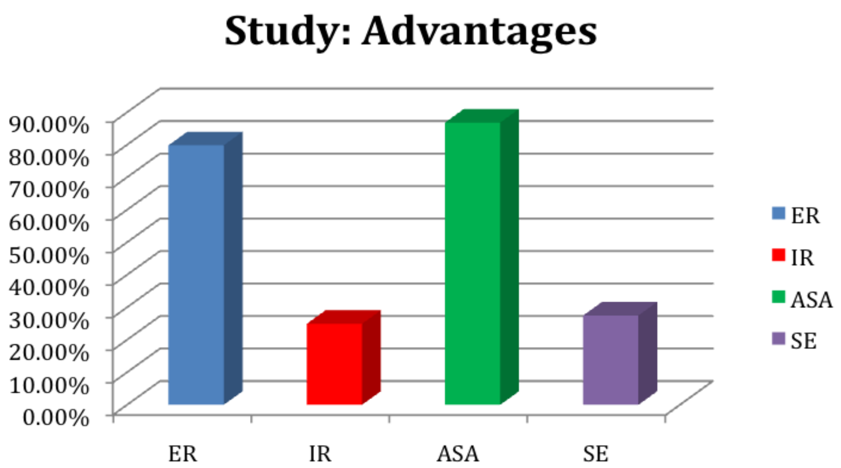


LMDI: Lack of motivation due to the nature of instruction, LT: Lack of time to study and understand the course material, LESH: Lack of established study habits, ACC: Amount of content covered, PDC: Perceived difficulty of content, SE: Self-efficacy, LS: Learning strategies, ACLE: Access to a conducive learning environment, LMTSforS: Lack of motivation for the subject.

Figure 4. *Perceived Factors that Make Receiving a High Grade in Science* Hard

e) *Perceived Advantages of Studying Hard for Science*

We also asked the participants to share their views on the perceived advantages and disadvantages of studying hard to achieve in science. The results show that the majority of participants (n=218) cited external rewards (e.g. getting high grades, getting a well-paying job), 68 participants cited internal rewards (i.e. developing a better understanding of natural world), 237 participants cited gaining the appreciation of significant authorities (i.e. teachers and parents), 75 participants cited gaining self-confidence as advantages of studying hard for science. See details in Figure 5.

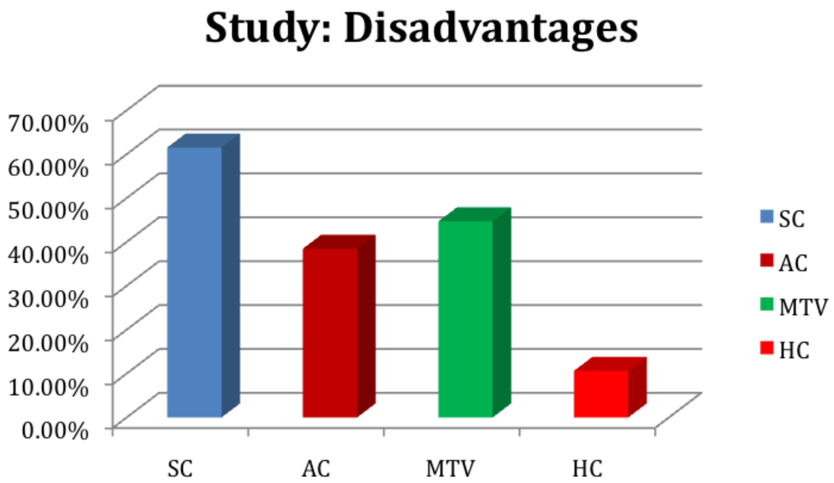


ER: External rewards,
IR: Internal rewards,
ASA: Appreciation of significant authorities,
SE: Self-efficacy.

Figure 5. *Perceived Advantages of Studying Hard in Science*

f) Perceived Disadvantages of Studying Hard for Science

In terms of perceived disadvantages, participants cited socialization cost (n=168), academic achievement cost in other subject areas (n=105), lack of motivation to study (n=122) and health cost (n=29) as disadvantages of studying hard (see details in Figure 6). When we asked the participants to tell us how likely they are to study hard for science after evaluating the advantages and disadvantages of studying hard for science 38% percent said they are likely to study harder than they do now, and 56% percent reported that there will not be any changes in their study habits; 6% did not respond to this question.

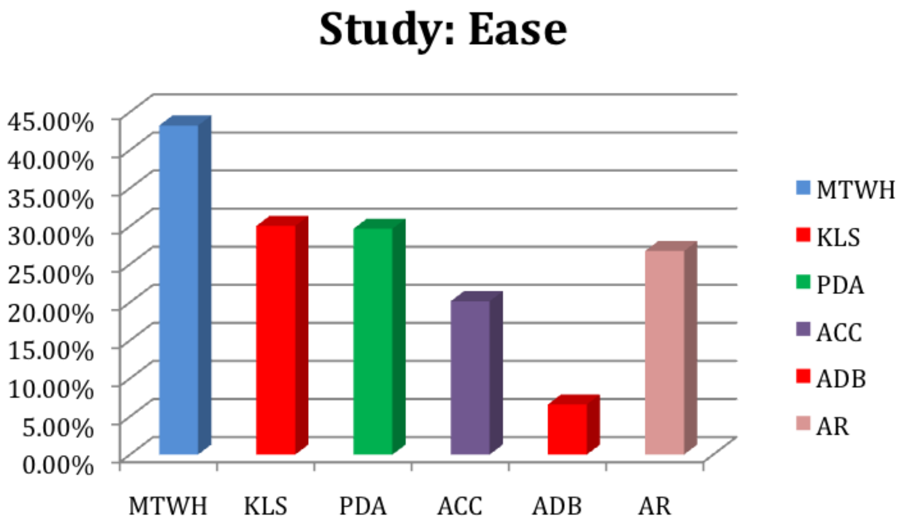


SC: Socialization cost,
AC: Academic cost,
MTV: Motivation,
HC: Health cost

Figure 5. *Perceived Disadvantages of Studying Hard in Science*

g) Factors that Make Studying for Science Easy

When we asked the participants to indicate the factors that would make it easier for them to study hard, participants cited the motivation to achieve as the most influential factor (n=118). The other factors that the participants thought would make it easier for them to study include: strategies (i.e. knowing how to study, knowing how to take notes in the classroom) (n=82), perception of the ease or difficulty of the assignments (n=81), the nature of the science courses (e.g. too many topics to learn, formulas to memorize) (n=55), awareness of the distant rewards (e.g. knowing that a science career can secure them a high economic and social position) (n=18), and access to quality resources and a conducive learning environment (n=73). See Figure 7 for details.

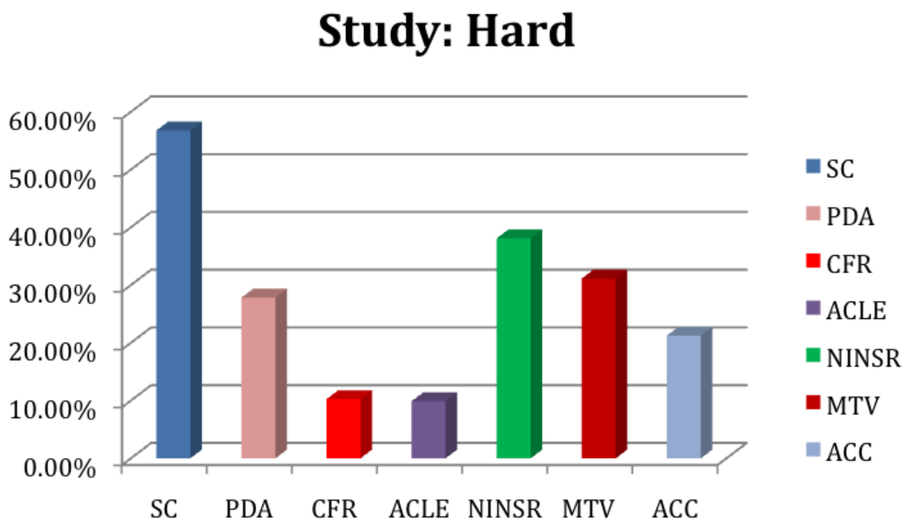


MTWH: Motivation to work hard,
KLS: Knowledge of learning strategies,
PDA: Perceived difficulty of assignments,
ACC: Amount of content covered,
ADB: Awareness of distant benefits,
AR: Access to resources and a conducive learning environment

Figure 7. *Perceived Factors that Makes Studying for Science Easier*

h) Factors that Make Studying for Science Hard

In terms of the factors that the students thought would make it harder for them to study hard, 155 of the participants cited socialization cost (e.g. giving up time from hanging out with friends), 76 participants cited the difficulty of the assignments, 104 participants cited the nature of instruction (e.g. formula-based science), 85 participants cited motivation to study, 27 participants cited access to a conducive learning environment, 28 participants cited responsibilities to his/her family, and 58 participants cited amount of content covered on the exams as factors that would make studying harder challenging for them. See Figure 8 for details.



SC: Socialization cost,
PDA: Perceived difficulty of assignments,
CFR: Commitment to family responsibilities,
ACLE: Access to conducive learning environment,
NINSR: Nature of instruction,
MTV: Motivation,
ACC: Amount of content covered.

Figure 8. *Perceived Factors that Makes Studying for Science Hard*

i) Advantages of Pursuing Advanced Learning Opportunities in Science

We were interested in knowing whether the students knew the advantages of pursuing advanced learning opportunities in science or not. The findings show that 164 participants cited internal rewards/motivation (e.g. a better understanding of scientific ideas), 123 cited external rewards (e.g. helps getting into a good university, receiving a good grade), 218 participants cited getting the appreciation of significant authorities (e.g. parents and the teacher) and 78 participants cited self-appraisal as the advantages of pursuing advanced learning opportunities in science. See details in Figure 9.

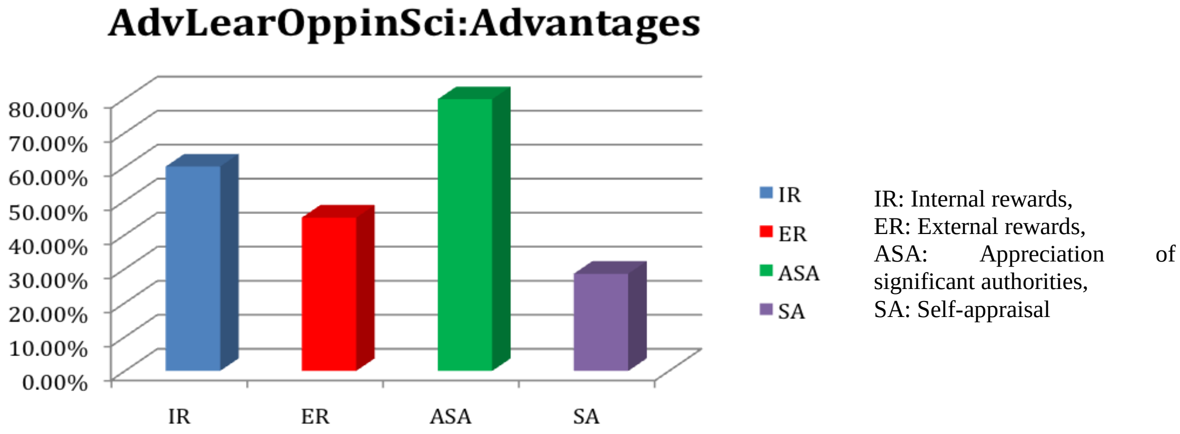


Figure 9. *Advantages of Pursuing Advanced Learning Opportunities in Science*

j) Disadvantages of Pursuing Advanced Learning Opportunities in Science

In terms of disadvantages of pursuing advanced learning opportunities in science, 136 participants cited lack of motivation to study hard, 96 participants cited socialization cost (e.g. giving up time from hanging out with their friends), 64 participants cited the academic cost (e.g. less time to study for other subjects), and 109 participants cited nothing. See details in Figure 10.

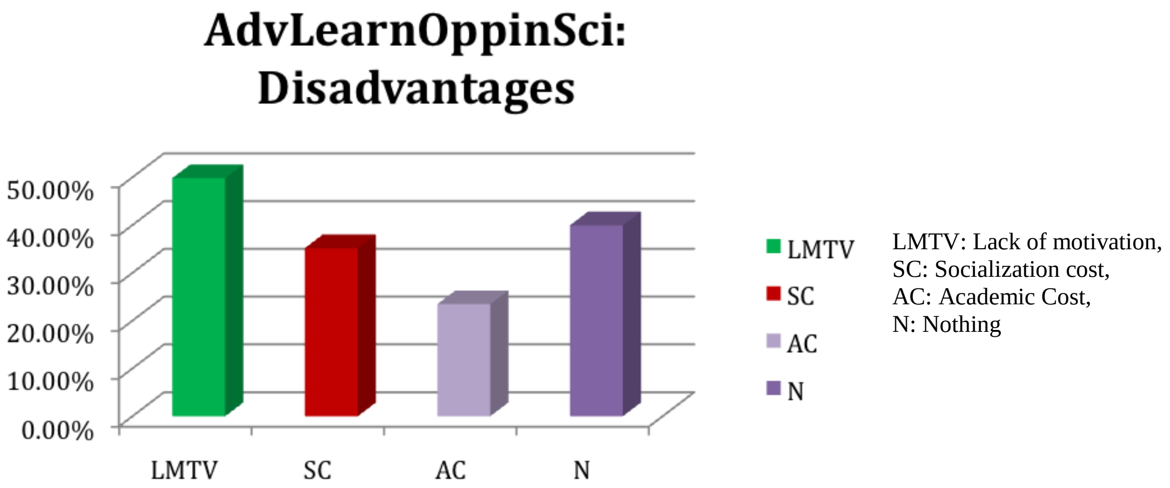
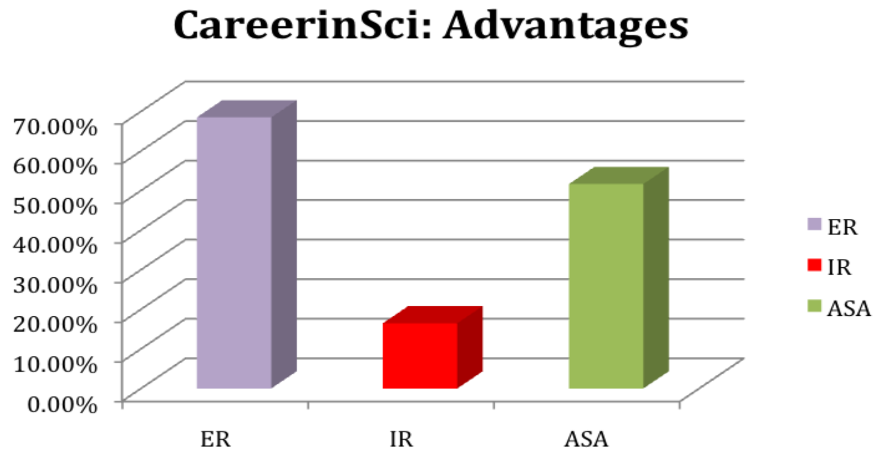


Figure 10. *Disadvantages of Pursuing Advanced Learning Opportunities in Science*

When we asked the participants to tell us how likely they are to pursue advanced learning opportunities in science after having evaluated these advantages and disadvantages 23% said they are likely to study harder than they do now, and 69 % reported that there will not be any changes in their study habits. About 8% of participants did not respond to this question.

k) Advantages of Pursuing a Science Career

We were also interested in understanding whether the students were aware of the advantages and disadvantages associated with pursuing a science career. The findings reveal that 187 participants cited external rewards (e.g. securing a prestigious economical/social position), 141 participants cited gaining appreciation of respected authorities such as parents and the teacher, 45 participants cited internal rewards (e.g. ability to make a contribution to the field) as the advantages associated with pursuing a science career. See details in Figure 11.

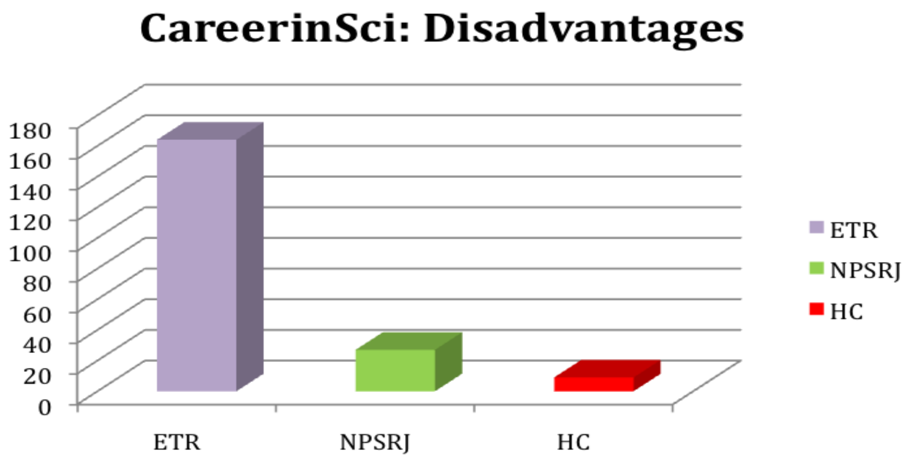


ER: External rewards, IR: Internal rewards, ASA: Appreciation of Significant Authorities

Figure 11. *Advantages of Pursuing a Science related Career in Science*

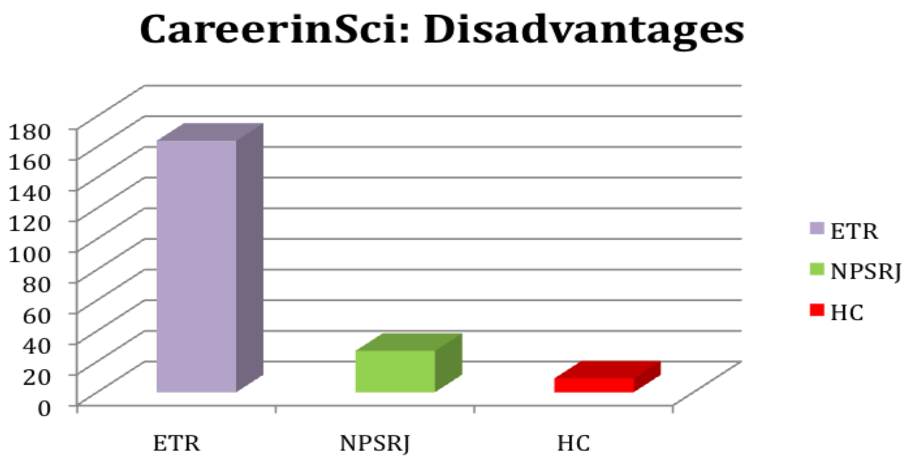
l) Disadvantages of Pursuing a Science Career

In terms of perceived disadvantages, 164 participants cited the amount of study time and effort it required, 27 participants cited the perceived negative factors associated with science related jobs (e.g. having to work hard, boring), and 9 participants cited health concerns as disadvantages of pursuing a science career (see details in Figure 12). When we asked the participants to tell us how likely they are to pursue careers in science after evaluating these advantages and disadvantages 48 % said they are likely to pursue a career in science, 41 % said they do not have the intention to pursue a career in science and 5% said they were not sure yet. The rest of them did not provide an answer for this question.



ETR: Effort and time required, NPSRJ: Negative perceptions about science related jobs, HC: Health cost

Figure 12. *Disadvantages of Pursuing a Science related Career in Science*

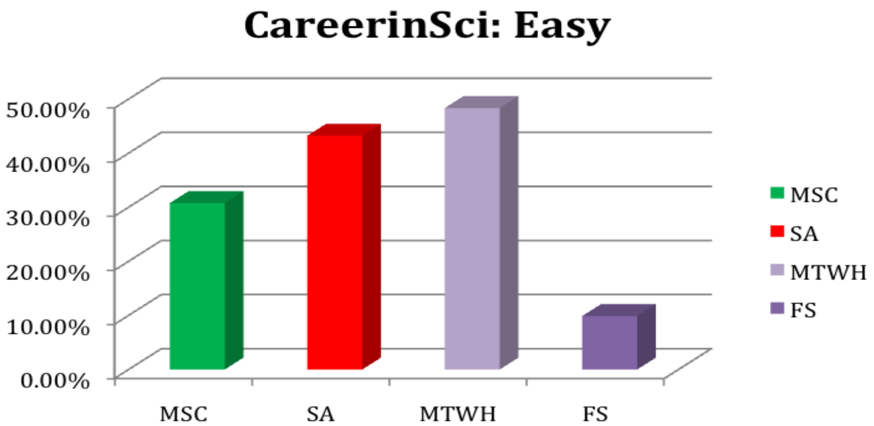


ETR: Effort and time required, NPSRJ: Negative perceptions about science related jobs, HC: Health cost.

Figure 12. *Disadvantages of Pursuing a Science related Career in Science*

m) Factors that Make Pursuing a Science Career Easy

In terms of the factors that they thought would make it easier for them to pursue a science career, 84 participants cited motivation to want a job in science, 118 participants cited self-efficacy to do well in science, 132 participants cited motivation to study hard, and 27 participants cited family support as factors that would make it easier for them to pursue a career in science. See details in Figure 13.

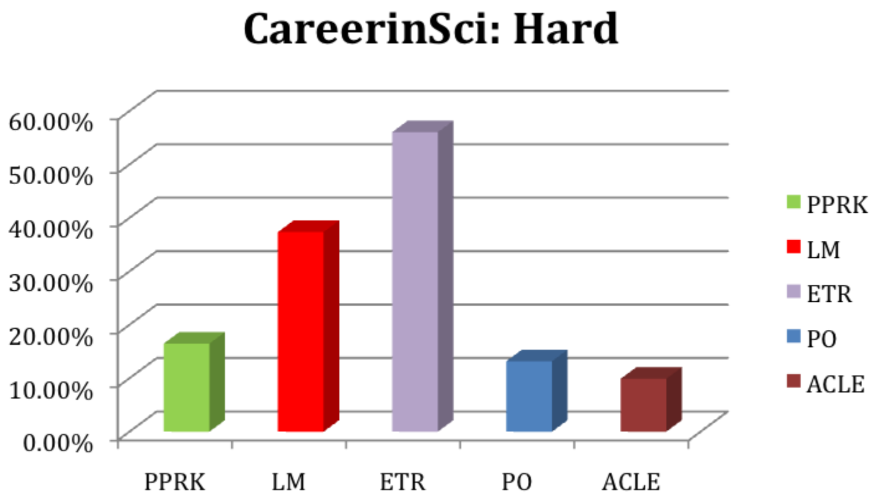


MSC: Motivation for a science career,
SA: Self-Appraisal,
MTWH: Motivation to work hard,
FS: Family support

Figure 13. *Factors that Make Pursuing a Science related Career Easy*

n) Factors that Make Pursuing a Science Career Hard

When we asked the participants to indicate the factors that would make it harder for them to pursue a science career, 45 participants thought it required knowledge of many subjects such as physics, chemistry and mathematics, 102 participants cited the lack of motivation to want a science related job, 153 participants cited not putting the required effort into studying, 27 participants cited not having access to a conducive learning environment, and 36 cited their knowledge of the unemployment rate as factors that they thought would make it harder for them to pursue a science career(see details in Figure 14.



PPRK: Perceived pre-requisite knowledge,
LM: Lack of motivation,
ETR: Effort and time required,
PO: Perceived outcomes,
ACLE: Access to a conducive learning environment

Figure 14. *Factors that Make Pursuing a Science related Career Hard*

Summary of Findings

a) Factors Positively Impacting Students' Achievement in and Attitudes towards Science

The qualitative analysis of participants' responses indicates that students provided diverse reasons for their acceptable performance in science and their positive attitudes towards science.

The findings show that there is a relationship between receiving higher grades in science and self-efficacy to pursue advanced educational opportunities in science. Students who have high grades are also the ones who feel confident about pursuing advanced educational opportunities in science and reported positive attitudes towards science and science careers.

Students' responses indicate that when they receive a high grade, they are more likely to spend extra effort and work harder to maintain their academic position. They expressed that they would invest more effort into maintaining their high grades, because high grades give them a prestigious social position among peers, family and teachers. Students also emphasized the immediate feeling of satisfaction achieved by receiving high grades as the justification for the effort they were willing to put into studying for science. Although the majority of students were conscious of the rewards (e.g. getting a well-paid job) that they could achieve by pursuing a career in science, only a small number of participants felt confident enough to pursue a science related career post compulsory education as the justification for the effort they invested into studying for science. However, the students who had a close family member studying in a science or engineering field were cognizant of the future job opportunities in the science and engineering fields. This recognition also motivated them to invest extra time into studying science and performing well in science courses.

Those who were able both to see the benefits of a career in science and their abilities to do well in science spent extra time studying and indicated a higher motivation for receiving high grades in science. The students who fell under this category also were those that were able to see the role of a science career in offering a prestigious social and economic position in society. However, being conscious of external rewards such as the potential for getting a well-paid job in science alone did not motivate students to spend extra time and effort into studying for science. Not surprisingly, the students who lacked self-efficacy to pursue a career in science were from low-income families and noted a lack of access to a conducive learning environment at home as one of the distractors for them to invest time into studying for science.

Students who were conscious of their parents' and teachers' explicit appreciation of their high performance in science reportedly spent extra time studying science. This was done in an effort to avoid disappointment from the authorities that they respected the most. While the majority of participants believed that their hard work on assignments resulted in them receiving better grades on unit tests, a sizable number of them (n=53) did not think that investing extra effort into studying for the tests or homework would help them to perform better in science. Interestingly, only few participants acknowledged that there is a high correlation between receiving a high grade and developing mastery of the content taught in their classrooms. Not surprisingly, the majority of the participants did not cite the mastery of content and curiosity for understanding the complexity of the natural and physical world as a justification for the positive attitudes that they held towards science or the extra effort that they invested into studying science. The two justifications that the participants provided for investing extra effort into studying for science include: receiving higher grades and securing the appreciation of significant authorities such as the parents and their teachers.

Factors influencing students' decisions to pursue advanced learning opportunities in science include avoiding their teachers' and family members' disappointment, self-efficacy and the awareness of the social and economical position they may be able to achieve through a science career. Given the importance of family values and the relationships between parents and their children in developing countries such as Turkey, this result is not surprising. However, this result has significant implications for boosting students' interest in science and increasing their level of achievement in science. If, in fact, family plays such a significant role in the decisions that students make in terms of the effort that they put into studying for science, schools should design educational programs that will help the parents to acquire knowledge, skills and resources to better support their children's education in school. For instance, students whose parents had received an education beyond high school cited that they had access to the educational materials related to famous scientists and read them more frequently than their counterparts whose parents did not have such a level of education. The parents who have less education may need further guidance to support their children's education related to science. Such educational opportunities can help students to develop positive attitudes towards science and are more likely to help them achieve in science at higher levels than they are able to now. These results raise the question of" What should the nature of these educational programs be? How they should be delivered? How should their impact be measured?" We invite the science education community to consider answers to these questions.

b) Factors Negatively Impacting Students' Attitudes towards Science

Factors contributing to students' negative attitudes and their underperformance in science courses were diverse. The students who showed negative attitudes towards science were the ones who had low grades in science. These students reported the following challenges that they faced for studying science: peer pressure, not understanding the content of the lessons, too much content to be learned and access to communication and entertainment technologies such as cell phones and video games. The participants noted that access to such communication and entertainment technologies made it harder for them to study for science. Not being able to study enough to receive a high grade in science negatively impacted their self-confidence to show further interest in science. These students also indicated that they did not have time to practice questions and problems to become successful in science, as addressing their socialization needs took priority over addressing their academic needs. These students also mentioned that science is a difficult subject and it covers a lot of material, which makes it harder for them to comprehend on their own. This we believe is a sign of low self-efficacy (Bandura, 1997). Bandura states that students with high self-efficacy are more likely to show resiliency when faced with difficult situations and those with low self-efficacy are more likely to quit when faced with difficult problems. The students who held negative attitudes towards science stated that they did not like to listen to the teacher and ended up distracting the learning of others to address their boredom in class. These students also mentioned that there are too many formulas for them to memorize in order to become successful on unit tests. It can be argued that because physical science courses are often taught through a mathematical framework, students associate conceptual understanding of key scientific theories with their ability to use the algorithmic formulas to solve algorithmic problems in science. This finding highlights the importance of teaching science for conceptual understanding. In addition, findings indicate that the students were more interested in learning science through laboratory and teacher demonstrations than they were through teacher-led lectures. However, we are not sure if students like these kinds of instruction because such instruction helped them to better understand the science content or simply because laboratory-based learning experiences helped them to "have fun" while learning science. Perhaps future studies can shed some light on this.

CONCLUSIONS

The findings reported in the previous section lead us to draw several conclusions. These conclusions are related to understanding how grades influence students' self-efficacy in relation to science achievement, the influence of significant authorities in children's lives on their achievement and interest in science and science careers, and the influence of science curricula and instruction on students' interest and achievement in science. We elaborate on each of these conclusions in the following paragraphs.

a) Conclusion 1

The first conclusion we draw from the findings is related to the value students place on grades and the factors that influence the grades students receive in science courses, along with factors that make it easier or harder for them to receive a high grade in science. The results show that the majority of students are conscious of the benefits of grades in science. Students cited developing self-efficacy and securing appreciation of and avoiding the disappointment of significant authorities (i.e. parents and teachers) in their lives as the main benefits of receiving high grades in science.

The results show that significant authorities (i.e. parents and teachers) in a student's life have the highest influence on students' motivation to engage in immediate classroom learning experiences, their achievement in science and interest in pursuing careers in science post secondary education. Despite parents' influence on students' interest and success in science, we know little about how educators capitalize on this influence to motivate their students to succeed in science and to consider science as a career for the future. However, we also see this as a potential problem for students' learning in science and their identity development in relation to science. Our additional findings justify our concerns. The findings show that the majority of participants are interested in learning science either because of external benefits or to secure the appreciation of their parents and teachers and not for satisfying their curiosity to understand the complexity of the nature. Such a disposition may be a direct result of the science curriculum and the teaching strategies used to deliver the curriculum. These findings show that science curricula and instruction fail to help students to develop curiosity for understanding the complexity of the natural world. For instance, only 45 participants reported "increasing further interest in science" as a benefit of receiving high grades in science. If students continue to engage in science only for external reasons (e.g., appreciation of parents or the teacher), they may not be able to develop scientific identities (Roth & Tobin, 2007). By capitalizing on the parents' and teachers' influence on students, and by equipping parents and teachers with the understanding, knowledge and skills needed to promote students' scientific identity development, we can provide a better service to the field of science (Barton, 1998). If we can achieve this, students will be engaged in the learning of science primarily for its intellectual merit, rather than for securing the appreciation of significant authorities in their lives (Gilman & Anderman, 2006). Elliot and Thrash (2001) state that students with a mastery goal orientation strive to acquire new knowledge and skills. Therefore, emphasizing students' interest in science by emphasizing its internal rewards will encourage students' meaningful participation in science learning and nurture their identity development in relation to science.

b) Conclusion 2

The socialization cost of achievement in science is the main distracter to students' academic success and interest in science. Most students cited that trying to achieve in science will cost them a significant amount of their leisure time and that they were hesitant to give up their leisure time in exchange for success in science courses. We interpret this finding in the following manner. First, classroom instruction fails to engage students in meaningful learning, and thus fails to help students to develop conceptual understanding. For instance, 94 participants stated, "the effectiveness of teacher" as a factor that can make receiving a high grade in science easier, 146 participants stated that lack of motivation to learn from classroom instruction makes receiving a high grade harder, 104 participants cited the nature of instruction (e.g. formula-based science) as a factor that makes studying for science harder and 76 cited the difficulty of assignments as a factor that makes studying for science harder.

These statements lead us to conclude that students do not believe in the effectiveness of the instruction they receive, nor do they believe that the type of instruction employed in the classroom motivates them to learn science. For instance, 136 students cited lack of motivation to study harder as the main reason for not being willing to pursue advanced educational opportunities in science. In order to make up for the time lost by "listening to the teacher talk in the classroom and taking notes" they feel like they need to spend a significant amount of time on their own to understand the concepts covered in the lessons. This problem can be minimized by increasing science teachers' pedagogical content knowledge (PCK). Teachers with sophisticated PCK are more likely than those who do not have such knowledge to help their students to develop conceptual understanding and engage in meaningful learning of important science concepts and thus motivate them to learn in the classroom (Park & Oliver, 2008). If students can be motivated to learn science in the classroom and are able to develop conceptual understanding in the classroom, they may not feel the need to spend substantial amounts of time outside of the classroom to succeed in science courses. Perrier and Nsengiyumva (2003) state that the "affective dimension is not just a simple catalyst, but a necessary condition for learning to occur" (p. 1124). It follows that teaching science in a way that can motivate students to learn will lead them to develop positive attitudes towards science, science learning and science careers (Koballa & Glynn, 2007).

c) Conclusion 3

A significant number of participants indicated that they did not have the motivation to study and lack established study habits such as taking good notes during teacher instruction. This result can mean two things. First, these students establish a link between taking good notes and becoming successful in science. Second, it shows that teachers emphasize students' acquisition of scientific facts and their memorization of the content delivered in class instead of emphasizing students' conceptual understanding and their ability to apply the scientific knowledge gained during instruction to new contexts. This problem can be addressed by increasing the quality of classroom instruction and by making a shift in the purpose of classroom instruction in science. If science teachers can teach science meaningfully and empower their students with knowledge and skills to apply their knowledge to unfamiliar contexts, students may be able to perform well on unit tests without having to memorize the facts of science and regurgitate them on the end-of-unit exams. As a result, they may develop self-efficacy to achieve in science and develop positive attitudes towards science and become future scientists.

Two main factors that impacted students' decision to pursue a science career include: self-efficacy to do well in science (n=118) and motivation to study hard (n=132). It follows that teachers of science should boost their students' confidence to do well in science and nurture their perceptions of themselves as future scientists. Two factors that determine students' self-efficacy to do well are grades that they receive in science courses and their perceptions of how well they can do on the university entrance exam. We believe that students' poor performance in science courses is the result of many factors, but the most important factors include the nature of instruction that takes place in the classroom, having established study habits and access to sufficient and appropriate resources needed to learn science. If instruction is not effective enough and students do not know how to study for the material outside of the school and do not have a conducive learning environment or sufficient resources, they may not be able to receive a high enough grade to boost their self-confidence.

DISCUSSION

The participants' responses indicate that multiple factors play a key role both in their success in science and the attitudes that they hold towards science. These factors can be categorized as external and internal. The majority of high achievers in this study "worked hard" in science either to get ahead of their peers, to perform well on standardized tests that open doors for further opportunities for them post compulsory education or to make their families proud of their success. Not only were these students able to see the big picture and understand the value of becoming academically successful in the short term (i.e. receiving a high grade) and the long term (i.e. getting a good job in science will benefit them both socially and economically), they also knew how to become academically successful in science. For instance, those who were able to succeed in science also had knowledge of strategies that made the learning of science easier for them.

These students knew that they needed to listen to the teachers' lectures and directions very carefully, were not afraid of asking questions when they did not understand something, and engaged in practice problems more frequently than those who indicated a negative attitude towards science. They also understood that if they worked hard enough, they would be able to succeed. As a result, these students had developed self-confidence in their abilities to become successful in science partly because of the history of their academic success in school science. Although they acknowledged that science is a hard subject to learn, they were convinced of their ability to do well in science. Moreover, this belief in their self-efficacy to do well in science encouraged them to invest extra time to study for science courses. Finally, the acknowledgement of their success by their teachers and family members motivated them to do well and to continue to receive praise from adult authorities such as their parents and the teacher. These behaviors that the students display are very consistent with the assumptions of the performance-goal orientation theory (Ames, 1992). This theory suggests that performance-oriented students are concerned with their ability to do well in science relative to others and with the perceptions of those they respect (i.e. the teacher, the parents) of their ability to perform a task. Crawley and Koballa (1992) maintain that "underlying the performance of target behavior is an assessment of personal consequences, social support and self-efficacy" (p. 42). When students' competencies are determined solely by how well they perform on standardized tests, it can have a significantly negative impact on the attitudes of those who cannot perform well on standardized tests and thus marginalize them in learning science.

Although the low performing students were also cognizant of the potential benefits that a career in science could offer to them or the immediate benefits of receiving a high grade in science, they lacked self-efficacy to become successful in science. Most of these students made such comments as, "I am not the type who can do well in science". However, this position was mainly influenced by their past academic history in science, which was determined by test scores. These students had not had a successful academic history in science (based on their grades in school). Another factor that impacted students' attitudes towards science and justified their failure in science is the intensity of the topics covered in science in comparison to other subject areas. Students do not find the number of science hours offered at high school to be sufficient for them to comprehend and assimilate all of the topics covered in the science curriculum.

Some students blamed the teacher for their lack of understanding of the topics covered in science courses. It could be the case that these students are more concerned with the mastery of content than in showing competency through test scores (Ames, 1992). In fact, these students stated that their teachers moved too fast, and they could not comprehend the course material. Thus, when the goal of classroom teaching shifts from teaching content for the purpose of test preparation to making sense of the scientific theories and laws through instructional practices informed by the epistemologies of constructivism and inquiry, there is the potential that these students will develop positive attitudes towards science (Kaya & Geban, 2011). This is the case, because when students understand the material presented to them, they are more likely to develop self-efficacy to pursue advanced educational opportunities in science (Cavallo & Laubach, 2001; Kan & Akbas, 2006). Kan and Akbas (2006) found self-efficacy to be a strong predictor of chemistry achievement. Finally, because the content of lesson did not interest them, they did not engage in learning in ways that would support their success in science. Interest has been shown to bring about improvements in students' learning of science (Krapp, 2002; Singh, Granville & Dika, 2002).

The results show that classroom instruction has a significant impact on students' attitudes toward science. The learning of students in science classrooms is limited, because most teachers in Turkey teach to the test. All students are required to take a very competitive nationwide standardized exam upon graduation from high school. Only a small percentage of students are able to enter the university. Entrance to the university is based on students' test scores on the exam, therefore, most teachers tend to prepare their students for the test and focus on drill and practice tests, rather than promoting conceptual understanding in advanced science courses through active learning strategies that give students the opportunity to develop meaningful understanding. Most school administrators promote this type of teaching because test scores and success rates on the university entrance exam determines the popularity of the school. Students who are placed in advanced science courses place a great emphasis on receiving a higher grade, as a high GPA in high school influences their scores on the nationwide standardized exam. In spite of their desire and interests to receive a high grade on the nationwide standardized university entrance exam, students are interested in hands-on science learning. For instance, most students indicated that they are very interested in seeing teacher demonstrations in science courses more frequently than they do now. They also wanted to learn science through laboratory-based science activities. However, it is hard for teachers to teach science in such ways due to several factors.

First, teachers in most high schools lack resources to teach science through laboratory-based activities. Second, most high school science classrooms are overcrowded in Turkey (the average classroom hosts 45 students), which makes the teaching of science through laboratory activities very difficult, if not impossible. Finally, most teachers are pressured to teach as much content as possible in an effort to better prepare their students for the nationwide standardized university entrance examination. These learning goals that the teachers promote (whether intentionally or unintentionally) impact the type of goals that the students adopt for themselves (Meece, Herman, & McCombs, 2003). As evidenced in the findings of this case study, the national educational policies, the nature of the science curriculum it promotes and how it is being taught influence students' attitudes towards science and their underperformance in science.

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