WHO CHOOSES SCIENCE? THE ASPIRATIONS FOR SCIENCE OF ACADEMICALLY ADVANCED HIGH SCHOOL STUDENTS

by

MISOOK HEO

(Under the Direction of Bonnie Cramond)

ABSTRACT

Guided by social-cognitive theories of motivation, this study investigated academically advanced high school students' aspirations for majoring in science in college. The participants, South Korean high school students enrolled in three special high schools for the talented, filled out a questionnaire which consisted of Likert-type questions and open-ended questions. Most of the Likert-type items were adapted from the Motivated Strategies for Learning Questionnaire (MSLQ). Six students also participated in follow-up individual interviews. The following factors were assessed and compared according to gender and level of science aspirations: self-efficacy, value of science, extrinsic goals, intrinsic goals, control of learning belief, test-anxiety, and perceptions of parental support. Students' extra-curricular science activities, self-concept of their own strengths for science learning, rationale for choosing or opting out of science, and personal experiences related to science were also examined. The quantitative data were analyzed by structural equation modeling (SEM), and the qualitative data were analyzed by inductive analyses. The statistical analyses indicated that advanced students' aspirations for science are explained to a large degree by their value of science and perceptions of parental support. The effect of parental support was greater on females' aspirations than on males'. Furthermore, the qualitative analysis found that students' positive experiences with science enhanced their value of science as important for their self-concept and future career. Also, parents contributed to the aspirations for science of their sons and daughters in different ways. This study provides parents, teachers, and educational policy makers with some suggestions for the educational practices and policies that can help talented children develop aspirations for science and advance in the scientific fields. Similar research in different cultures is warranted to determine how to effectively support talented students' accomplishments in science.

INDEX WORDS: Advanced students, Aspirations for science, Choosing science, Control of learning, Extra-curricular science activities, Extrinsic goals, Gender differences, Intrinsic goals, Parental support, Science Motivation, Self-efficacy, Test-anxiety, Value of science

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A Dissertation Submitted to the Graduate Faculty of the University of Georgia in Partial Fulfillment

of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2008

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December 2008

DEDICATION

To my mother and late father who dedicated themselves to educate me better, and build the foundation for my current achievements

ACKNOWLEDGEMENTS

I am very grateful to my committee for their professional services and encouragement which guided my research until I completed my dissertation. In particular, my major professor, Dr. Cramond, provided feedback and guidance which helped me from the determination of research topic to my defense. Her encouragement gave me the impetus to complete this project. My knowledge in the statistical methods used in this research was formulated mostly in Dr. Bandalos's classes. Dr. Bandalos's critical comments based on her careful review of my writing also enabled me to improve my questionnaire and statistical analyses. Dr. Glynn's suggestions led me to focus on motivation and to include open-ended questions in the questionnaire used, and his questions extended my understanding of the phenomena I studied. Dr. Hebert helped me develop interview questions, and his detailed feedback improved my writing and promoted my confidence in the work. Besides my committee, Dr. Braxley, a faculty member in the Academic Enhancement program helped me edit my writing, and in the process her questions drove me to better clarify my ideas.

I deeply appreciate my parents' support for my education, which contributed to my becoming the first college graduate in my family. However, without my husband Jungsik's help and encouragement, my continuation in the Ph. D. program would have been impossible. My four children Sunok, Dohyung, Dowan, and Grace also endured my involvement in graduate study for several years. Moreover, they encouraged me to keep working on my dissertation whenever I expressed to them how overwhelmed I felt at times. In particular, my daughter Sunok helped my research in many ways including the translation of Korean transcripts into English. I am also very grateful to my parents-in-law. They cared for my sons in Korea and helped as one entered a high school for the academically advanced and as the other was admitted to college. Thanks to their sacrifices and efforts, I was able to concentrate on my doctoral studies for the last year and a half with the knowledge that my sons were being taken care of.

I wish to express my special thanks to the students who shared their thoughts and experiences for my research and the teachers who supported my data collection at their schools. In particular, I owe much to Dr. Heekwan Shin, Ms. Younghee Yang, Mr. Hoon Ahn, Mr. Hwajoo Ha, and Ms. Jinsun Jung for helping me to obtain access to the schools and administer questionnaires and conduct interviews.

I am very happy to acknowledge several special friends for their help in my study. Dr. Hyungsook Lee and Dr. Myunghwa Kho, who were senior to me in the graduate program at UGA, have provided me with timely advice that aided my progress. In addition, Hyungsook's review of my Korean translation of the questionnaire was critical for the improvement of the translation. Hyejung is my graduate colleague with whom I most frequently discussed the problems I confronted with regard to statistical methods. Her practical help often solved my problems, and our conversations often gave me a deeper understanding of statistical methods for educational research.

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CHAPTER I

INTRODUCTION

The importance of fostering human resources in the scientific fields is increasing as internationally economies are more dependent on scientific technology with problems such as global climate change and draining natural resources. In this regard, students' decreasing interest in the pursuit of scientific careers (Gallagher, 1993; Osborne, Simon, & Collins, 2003) and the marked underrepresentation of females in the hard sciences (Rayman & Brett, 1995) invoke concerns. Researchers have found that people who persist in science careers are likely to have had higher academic achievement and have taken more science courses in high school (Farmer, Wardrop, & Rotella, 1999). In addition, Zusho and Pintrich (2003) found that motivation influences achievement and choice more than previous achievement or aptitude does when the other factors are controlled for. Therefore, understanding of academically advanced high school students' motivation for choosing science should found the educational practices and policies to develop scientific talents. Why do some academically advanced high school students choose science, while others, equally as advanced, do not?

The purpose of this study was to explain and predict academically advanced high school students' aspirations for science, which was conceptualized as the intention of such students to major in science, math, or engineering in college. Given the concerns of females' underrepresentation in the sciences, an emphasis was put on explaining gender differences. Guided by the social-cognitive perspectives of motivation (Eccles and Wigfield, 2002), I investigated the influences of personal beliefs and experiences as well as parental support on individuals' aspirations for science. For measurement, I used the motivational scales of the Motivated Strategies for Learning Questionnaire (MSLQ: Duncan & McKeachie, 2005) and a parental support scale that was created for this study.

The following constructs were assessed in the context of learning science: self-efficacy, value of science, extrinsic goals, intrinsic goals, control of learning belief, test-anxiety, and perception of parental support. The definitions of the constructs in the present study are as follows: self efficacy which is the expectation of successful outcomes and confidence in mastering course contents and skills; value of science which includes beliefs in science as interesting, useful, and important; extrinsic goals which include goals to get better grades than other students and to show one's ability to important others; intrinsic goals which are challenge-seeking behaviors to master or to learn course contents and materials; control of learning belief which is a belief in the importance of one's own effort and appropriate strategies for learning; test-anxiety which includes distractions, concerns, negative feelings, and unpleasant physiological response (i.e., fast heart beating) with regard to science testing; perception of parental support which includes parents' concerns, expectations, encouragement, and support for science activities. In addition, open-ended questions and semi-structured interviews examined students' perspectives on their learning and choice of science as a major.

This study is unique in the samples used, the data types, and the analysis methods. All the participants were highly advanced students recruited from three special high schools in Seoul, Korea. To collect data, a questionnaire, consisting of Likert-type items and open-ended questions, and six semi-structured interviews were administered. The collected data sets were analyzed using mixed methods. Students' responses on the Likert-type items were statistically analyzed using structural equation modeling. This method is particularly useful for the estimations of parameters related to latent factors because it accounts for measurement errors. The SEM analyses supported the instrument's validity as a means to probe the motivational constructs related to science learning and also the hypothesized structural model that explains and predicts advanced high school students' science aspirations. On the other hand, the responses to the open ended questions were analyzed with regard to frequency of response categories, and the interview transcriptions were inductively analyzed. By incorporating the qualitative as well as the quantitative methods into the investigation, this study illuminates overall science motivational patterns among the groups of interest, as well as students' personal experiences related to science, which help us understand advanced students' development of science aspirations.

Theoretically, this study is significant in that it extends the expectancy-value theory (Eccles & Wigfield, 2002). The theory has posited that parents affect children's motivation behaviors indirectly through the mediation of value and expectancy beliefs. However, this study found that parents affect children's aspirations directly and more strongly than the personal beliefs. In addition, this study extends the existing literature on gender differences in science motivation, in which female advanced high school students have not been frequently studied. This study found that there are gender differences in the effects of parental support and personal beliefs on science aspirations of advanced students. Even though the findings were made using a sample of South Korean advanced high school students, the findings can provide a useful theoretical framework for more general motivational research.

This study is also expected to contribute to the development of scientific talents of academically advanced students. Parents, teachers, and educational policy makers will be informed of the important factors relevant to science aspirations; students' perspectives on science learning; and the influences of parents and current educational practices on students' science motivation. The information will help these groups facilitate educational environments and practices that promote students' aspirations for science and appropriately guide the advanced students who have already been motivated to choose science.

CHAPTER II

REVIEW OF LITERATURE

Research found that students' aspirations for college science degrees are influenced by various personal and environmental factors such as intrinsic interest, confidence in math and science, science activities, home background, vocational attractiveness, teachers, and science curriculum (Quihuis, 2002; Seymour & Hewitt, 1997; Woolnough & Guo, 1997). Some of the factors have also been found to be useful for explaining gender and ethnic differences in science program enrollments (Seymour & Hewitt, 1997). Thus, the current study was based upon a theoretical framework that addresses both environmental and personal factors and their interrelationships rather than a theoretical framework that views motivation either as a personality trait or an environmentally induced state (Dai, Moon, & Feldhusen, 1998).

The social-cognitive theories of motivation such as expectancy-value theory (Eccles & Wigfield, 2002), self-efficacy theory (Bandura, 1986), and goal orientations theory (Ames, 1992; Dweck & Leggett, 1988; Nicholls, 1984) have prioritized personal beliefs or goals as important influencers on one's cognition, affect, and behavior. In addition, these theories emphasized the effects of social environments and personal experiences on the development of beliefs and goals. Literature that addresses these theories and relevant research on students' science motivation as well as gender differences in the motivation are reviewed in this chapter.

Expectancy-Value Theory

According to Eccles and Wigfield (Eccles & Wigfield 1995, 2002; Wigfield & Eccles, 2000), students' academic choices, persistence, and performance are directly influenced by their beliefs about value and expectancy for success. The expectancy-value theory was developed based on Atkinson's achievement motivation model and later researchers' work (Eccles & Wigfield, 2002).

Atkinson's expectancy-value theory. Regarding the motivation to choose and persist in a task, Atkinson (1957) viewed people to have both motivation to achieve success and motivation to avoid failure. He explained the strength of each motivation as a multiplicative function of dispositional motives (i.e., a tendency to try to achieve or tendency to avoid failure), outcome expectancy, and incentive value of the outcome. In the model, the outcome expectancy was defined as a subjectively evaluated probability to succeed or to fail in the task; and the value of the outcome was inferred from the perceived difficulty of the task: the more difficult to achieve, the more pride in accomplishment or the less feeling of shame in failing. As a result, both outcome expectancy and value were dependent on perceived task difficulty, which was represented as a decimal between zero and one. Thus, a person's motivation turns out to be strongest if his or her perception of the confronting task is around .5 or moderately challenging. At this level, the task is perceived to be demanding, but not daunting.

Task-value beliefs. Atkinson's incentive value of a task has been modified and extended by Eccles and Wigfield (1995), who refined the construct of value by adding three distinct components—attainment value or importance of the task, intrinsic interest in the task, and utility or usefulness of the task. When applying the refined value beliefs, in contrast to Atkinson's model, the researchers have found that children in academic achievement contexts tend to value the tasks they can do well rather than valuing the tasks they perceive as difficult. Regarding the differential effects of each value component, Eccles and Wigfield (1995) have found that interest in math predicts junior high school students' intention to keep taking math, but both perceptions of interest and utility predict decisions to take math courses for high school students.

Expectancy for success. Atkinson's outcome expectancy has been used by Eccles and her colleagues without much modification. They defined expectancy for success to be "individuals' beliefs about how well they will do on upcoming tasks, either in the immediate or longer term future" (Eccles & Wigfield, 2002, p. 119). In addressing the concerns over the poorly differentiated motivational constructs in general and the ability related constructs in particular (Bong, 1996; Pajares, 1997), Eccles and Wigfield (2002) have argued that although self-efficacy indicates "broad beliefs about competence in a given domain" (p. 119), self-efficacy and expectancy for success are not empirically distinguishable among children and adolescents.

Development of expectancy and value beliefs. According to Wigfield and Eccles (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), children's cultural and social environments as well as their personal characteristics affect their expectancy and value beliefs. They have explained that students' expectancy and value beliefs are dependent on their short-and long-term goals, self-concept of abilities, and perceived identities, which are in turn dependent on personal characteristics, others' expectations, affective reactions, and previous experiences. In particular, they have emphasized that value beliefs are more saliently influenced by affect than by cognitive factors, to take into account the fact that motivational choice is not solely made by rational processes but with the influence of affective reactions and memories (Eccles & Wigfield, 2002). Previous achievement experiences, parents' beliefs, aptitudes, gender, and birth order have been assumed to directly influence affective reactions and memories. A diagram of the complex relationships among the factors is presented in Figure 1.

Furthermore, some researchers tried to extend the expectancy-value theory by incorporating an anxiety variable in it (Meece, Wigfield, and Eccles, 1990). Even though Meece et al. (1990) failed to find a significant roles of math-anxiety in mediating the effects of math ability beliefs and value of math on math performance and intentions to enroll math courses among junior high school students, they found that negative affect for math and math tests was significantly affected by each expectancy and value belief.

Gender differences in expectancy and value beliefs. Expectancy for success and value beliefs have been used to explain academic choice in science. Research has found that both beliefs positively influence the number of hard science courses taken throughout high school (Simpkins,

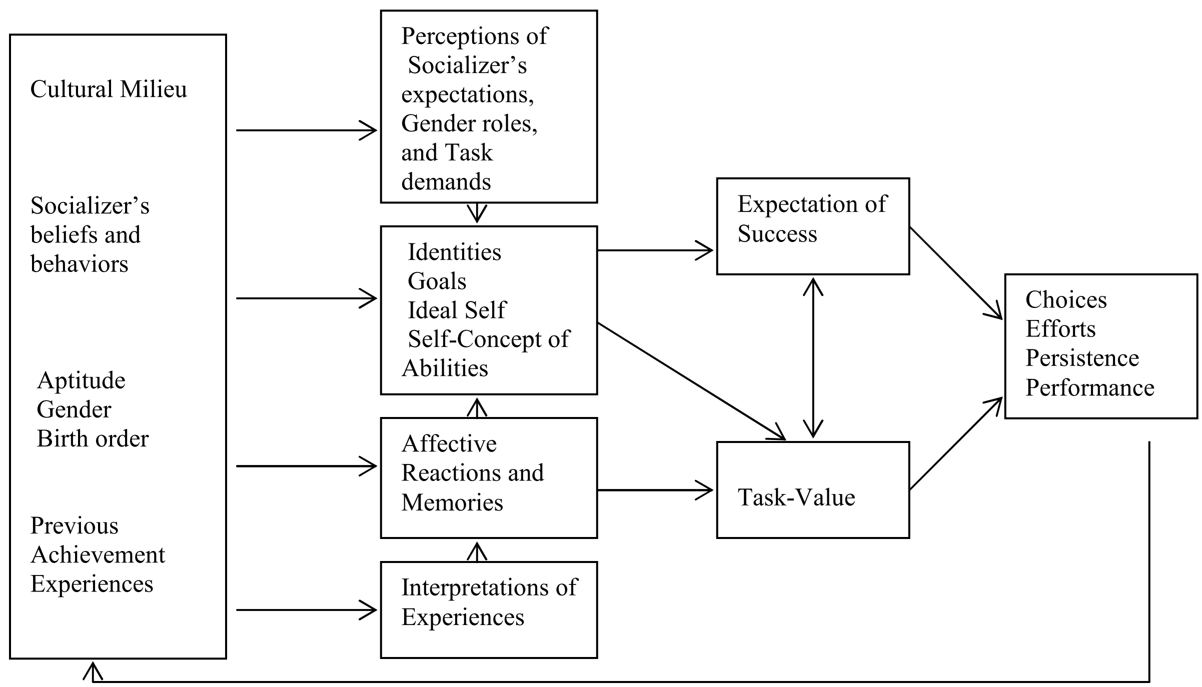

Figure 1. Expectancy-value model of achievement motivation. Adapted from "Motivational beliefs, values, and goals," by J. S. Eccles and A. Wigfield, 2002, *Annual Review of Psychology, 53*, p. 119. Copyright 2002 by the Annual Review. Adapted with permission of the author.

Davis-Kean, & Eccles, 2006) and aspirations for a college degree in hard science (Quihuis, 2002). Furthermore, Simpkins et al. (2006) have found that participation in out-of-school science activities positively influences later expectancy for success and value of science beliefs, which is more salient in male students than female students. Additionally, they have found that parent education is associated with fifth grade girls' science grades and science activities, yet it is associated with the number of physical science courses taken by boys in high school. However, neither of the two studies found significant gender differences in expectancy and value belief among a sample composed of adolescents living in a suburban area (Simpskins et al, 2006), nor among high achieving high school students who aspire toward a hard science degree (Quihuis, 2002). Moreover, Simpkins and colleagues (2006) did not find gender differences in either course grades or the number of hard science courses taken in high school. Nonetheless, there is research evidence that females who pursue a science career and those who do not differ in their value of science. According to Farmer, Wardrop, and Rotella (1999), females who are engaging in a science career tended to have valued math and science in high school significantly more than those who are engaging in a non-science career.

Recently, the research evidence that females are not significantly different from males either in expectancy and value beliefs or in performance has accumulated. However, research has also found females' lower rate of enrolling in college science programs, higher rate of attrition from college science programs, and lower engagement in science careers (Seymour & Hewitt, 1997). It appears that factors other than the beliefs and previous performance (e.g., parental support) should be included in the model of high school students' aspirations for science to account for the gender differences.

Achievement Goal Theories

Students' achievement behaviors, adaptive and maladaptive, have been related to the goals they endorse. Task-involvement goals (Nicholls, 1984), learning goals (Dweck & Leggett, 1988), and mastery goals (Ames, 1992) have been known to facilitate desirable learning behaviors, whereas ego-involvement goals (Nicholls, 1984) and performance goals (Dweck & Leggett, 1988; Ames, 1992) have been known to have undesirable effects on learning. Notwithstanding the overlapping effects of the goals, the researchers' assumptions and perspectives remain distinctive (Pintrich, 2000). Later, performance and learning goals have been further differentiated with the consideration of approach and avoidance orientation (Elliot & Harackiewicz, 1996; Pintrich, 2000).

Task-goals and ego-goals. Nicholls (1984) viewed that achievement goals are basically to gain competence or ability, and conceptions of ability can be differentiated according to their evaluation standards: "less differentiated [from self]" and "more differentiated" (p. 329). According to his explanation, students, whose conception of ability is less differentiated, tend to judge their ability and task difficulty with reference to their sense of mastery or understanding; whereas students, whose conception of ability is more differentiated, judge difficulty and ability through social comparisons of effort and outcomes. Thus, the former group endorses a task-involvement goal with the concern of "improving one's mastery of tasks"; whereas the latter group endorses an ego-involvement goal with the concern of improving "one's ability relative to that of others" (p. 329). Individuals' subjective experiences vary by goals. Task involvement goals entail engagement in challenging tasks, intrinsic motivation, and positive affect while ego involvement goals entail undermined interest in mastery and increased attribution of external factors. For example, a student who has task involvement goals would be one who chooses advanced science classes for the challenge, enjoys the stimulation, and feels pride in doing well. On the contrary, a student who has ego involvement goals would be more likely to take an easier class in order to ensure a high grade, and would attribute any difficulties in the class to factors such as luck, poor teaching, or fatigue.

Learning goals and performance goals. On the other hand, Dweck and her colleagues (Dweck & Leggett, 1988; Elliott & Dweck, 1988) believed that learning goals and performance goals are the most salient among children. According to Dweck and Leggett (1988), students who endorse learning goals are characterized as concerned with "increasing their competence," yet students who endorse performance goals are characterized as concerned with "gaining favorable judgments of their competence" (p. 256). The goals frame individuals' interpretations of events and foster contrasting response patterns of behavior, affect, and cognition in conjunction with perceived ability: mastery-oriented and helpless. Those who focus on learning goals are likely to choose challenging tasks to maximize the growth of their ability, in spite of the risk of being judged as having low ability by the teacher or peers. When confronted with difficulties, they tend to consider failures as opportunities to learn, enjoy challenges, monitor strategies and efforts, and finally enhance performance. Such experiences entail positive affect, pleasure or pride. However, students who focus on performance goals reveal different patterns of choosing tasks. In particular, when students who are oriented to performance goals have low self-competence, they tend to choose easy tasks, while those students with high self-competence are likely to choose more challenging tasks, at least when they perceive no threat of performance failure. Upon being confronted with difficult tasks, performance oriented students are likely to attribute failure to inadequate ability, which in turn threatens their self esteem and engenders anxiety. As they interpret effort as confirming low ability, they will not exert much effort, even when effort is most required, as in a challenging assignment. To make matters worse, negative affective feelings such as boredom, aversion, or anxiety distract attention and interrupt effective strategy use, resulting in deteriorated performance.

Personal theories of intelligence. Regarding the factors that influence goal orientations, Dweck and Leggett (1988) emphasized the importance of personal theories of intelligence. According to their theory, students who view their intelligence as increasing with learning tend to endorse learning goals; and students who view their intelligence as a fixed entity tend to endorse performance goals. There is some support for their theory. For example, when the effects of teacher's praise for intelligence and praise for effort on fifth graders' achievement goals and behaviors were compared (Mueller & Dweck, 1998), the results were as follows. Children praised for intelligence after the completion of a task were more likely to adopt performance goals and exhibit maladaptive motivational patterns identified in previous research (e.g., Dweck & Leggett, 1988): less interest, less persistence, attribution of failure to low-ability, and lower performance after a setback condition. In contrast, children praised for effort were more likely to adopt learning goals and to exhibit adaptive motivational patterns after a setback, which resulted in better performance than their counterparts.

Mastery goals and performance goals. However, Ames (1992) viewed mastery and performance goals as salient among students and attempted to explain the effects of classroom structures on students' goals. According to Ames, mastery goals put emphasis on effort to produce an outcome and involve self-referenced standards for success. The belief that the outcome depends on effort pushes individuals to remain motivated, persist, self-regulate, and adopt effort attributions; and a sense of mastery or improved competence serves as a criterion for individuals' evaluation of success. In addition, she indicated that mastery goals are associated with adaptive achievement behaviors such as preferring challenging work and having interest in and positive attitudes toward learning. Regarding performance goals, she explained that they have a focus on "one's ability and sense of self-worth" (p. 262). Students who adopt performance goals relate ability to better performance than others without much effort and estimate their self-worth according to their perception of ability. Thus, when they experience failure in spite of their heavy effort, their concept of their ability is likely to be threatened. In addition, Ames indicated that performance goals have contrasting effects to mastery goals, such as avoiding challenge, producing negative affect after failure but positive affect after easy success, and degrading self-competence.

Influences of classroom environments on goals. By contrast to Dweck and Leggett (1988), who have noted personal beliefs on intelligence as a salient predictor of goal orientations, Ames (1992) and Nicholls (1984) have noted that certain natures of tasks and environments predict goal orientations. Specifically, Ames identified classroom structures conductive to mastery goals in terms of the nature of tasks, practice of evaluation and recognition, and distribution of authority. Nicholls also identified conditions that produce either task or ego involvement. Presentation of moderately challenging tasks under conditions in which there is no psychological stress or salient extrinsic incentives predicts task involvement, whereas presentation of valued tasks such as tests under conditions that foster competition and induce self-awareness produces ego involvement.

Following Ames, a multitude of researchers has scrutinized the relationships among students' goals, learning, instructional practices, and classroom environments and has illuminated classroom practices and environments conducive to students' learning. For example, Nicholls, Cobb, Wood, Yackel, and Patashnick (1990) investigated the influence of constructivist instruction on second graders' goals (i.e., task and ego orientation, and task avoidance) and beliefs in causes of success in math classrooms. The constructivist classrooms encouraged dialogue and cooperative learning for problem solving. The researchers found that students in such classrooms were more likely to possess adaptive goal orientations and beliefs than those in traditional math classrooms where presentation of preconceived solutions was important. Among the students, task orientation was correlated with the beliefs in interest and effort, understanding, and cooperation for success in math; however, ego orientation was correlated with competitiveness. In another example of the relationship between classroom environment and goal orientation, Nolen (2003) found that high school students' perceptions of their teachers' goals (i.e., mastery, performance, or independent thinking) and classroom climate (i.e., competitive or cooperative) significantly predicted their achievement and satisfaction with learning, although she failed to find significant effects of perceived environments on students' goals or preferred strategies. Specifically, classroom level (aggregated) perceptions of the classroom environment characterized by emphasis on ability, requirements of fast-paced learning and lots of memorization, and more emphasis on correct answering than on understanding negatively predicted individual students' achievement when reading comprehension was controlled for. Yet, a focus on learning positively predicted satisfaction with learning. No gender difference in achievement across different classroom environments was found.

Furthermore, Deemer (2004) researched the effects of high school teachers' perceptions of school culture (mastery or performance oriented) on their instructional practices and their students' goal orientations. According to Deemer's path model, teachers who have high teaching efficacy tended to perceive a mastery school culture and possess an incremental view of intelligence. Teacher's perceptions of a mastery school culture, in turn, influenced their mastery oriented instructional practices and their students' mastery goal orientation. Inconsistent with the prediction of Dweck and Leggett (1988), however, theories of intelligence reported by teachers had no significant relationship with either their mastery or performance oriented practice.

Classroom teachers often have concerns over students' self-deteriorating behaviors. According to Urdan, Midgley, and Anderman (1998), in contrast to attribution, which is a causal explanation of obtained outcomes, self- handicapping strategies [e.g., "procrastinating, fooling around, getting involved in many activities" (p. 101)] are used to provide cause for subsequent performance by some students who are concerned about looking incompetent. The researchers found that such behaviors among fifth graders were significantly associated with their perceptions of classroom goal structure (ability or task goal), academic competence, GPA, and gender as well as teachers' reports of instructional practices (task or ability oriented). According to their hierarchical linear full model, teachers' ability-goal oriented practice and students' perception of classroom as ability-goal oriented could predict students' use of self-handicapping strategies (γ = .15 and .29, respectively), In particular, boys, students with lower GPA, and students with lower academic competence were vulnerable (γ = -.16, -.23, and -.22, respectively). However, race and SES were non-significant predictors. This study invokes concerns over instructional practices that put emphasis on competition and test scores. Contrary to teachers' intention to promote students' efforts, such practices actually seem to facilitate avoidant behaviors among some students whose GPA and academic competence are low. Boys are especially vulnerable.

Approach and avoidance dimensions of goals. In contrast to the research that has identified performance goals' negative effects, some research has found more desirable or comparable effects of performance goals to mastery goals. For example, Elliot and Harackiewicz (1994, 1996) found that performance goals can be beneficial to college students who have high achievement orientation. Under given norm-referenced target goals in playing game experiments, students high in achievement orientation enjoyed the tasks the most. Further, Elliot and Harackiewicz (1996) argued that the approach-avoidance dichotomy is more congruent with research findings regarding the effects of goals upon intrinsic motivation, than the mastery-performance dichotomy. They proposed incorporating approach and avoidance tendencies into performance goal orientation as independent dimensions. Specifically, the researchers conceptualized an avoidance tendency as “an avoidance orientation grounded in [self-protective] self-regulation according to potential negative outcomes” (p.462). Their experimental studies (1996) found that undergraduate students’ performance-avoidance goals degraded intrinsic motivation via lessened task engagement but not via perceived competence, in enjoyable game experiments.

Later, Pintrich (2000) contended that a mastery orientation also has an avoidance dimension which is concerned with “not ‘being wrong’… only in reference to the self or the task” (p. 100). He claimed that certain perfectionists instantiate mastery-avoidance goals by avoiding a task to avoid being wrong. This belief structure would cause students to avoid taking mathematics and science courses that might be challenging in order to avoid getting poor grades.

As well as the multidimensional aspects of performance and mastery goals, their differentiated interaction effects have also been noted. Pintrich (2000b) investigated a junior high school math class with a focus on the effects of multiple goals on students’ motivation, affect, strategy use, and performance. Four groups were created using mean splits: high mastery/high performance, high mastery/low performance, low mastery/high performance, and low mastery/low performance. He found that high mastery/high performance students developed no significant negative affect or maladaptive strategy use compared to high mastery/low performance students that had been associated with the most adaptive motivational pattern in previous research.

Taken together, achievement goals frame individuals’ cognition, affect, and interpretation involved in achievement situations. Research in this line has identified multiple types of goals and their effects on academic choices, persistence, study strategies, and performance. In addition, the theories and relevant empirical studies have informed of instructional practices and classroom environments conductive to students’ adaptive motivation and learning behaviors.

Self-Efficacy Theory

Bandura (1986, 1989, 2006) emphasized personal agency as a human characteristic, which makes changes not only in one's behaviors but also in one's environment. He contended that one's beliefs about one's own ability to execute a certain task, self-efficacy beliefs, are the central mechanism of personal agency, which determines whether one will choose to do the task, how much effort one will exert for the task, and how long one will persist in the task.

Origins of self-efficacy beliefs. Regarding the origins of individuals' self-efficacy beliefs, Bandura (1986) has identified four sources: mastery experiences, vicarious learning, verbal persuasion, and physiological responses. First, self-efficacy is raised by successful mastery experiences, but is lowered by repeated failures. However, once individuals have developed strong self-efficacy, their efficacy may not be tainted by occasional failure. Second, individuals' efficacy beliefs are influenced by others' performances. Successful performance of others, who are considered to have similar ability to the observer, will increase the observer's self-efficacy for the comparable tasks. Yet similarly competent others' unsuccessful performance despite high efforts will undermine the observer's self-efficacy and further efforts. Third, verbal encouragement from significant others that one has the ability to accomplish given tasks can lead the person to exert enough effort to succeed and develop a sense of self-efficacy. Lastly, people judge their efficacy partly from high arousal as well as physically uncomfortable symptoms such as fatigue and pains. Such physiological states can indicate their lack of self-efficacy and hamper subsequent performance.

Lack of discriminance among ability beliefs. According to Pajares (1997), there are some conceptual differences between self-efficacy and other self-concepts of competence. Self-efficacy is task-specific rather than domain-specific. However, self-concept is belief in ability at a more general level (e.g., I am quite good at physics.) and includes evaluation of feelings of self-worth associated with the ability. Concerning the differing effects of self-efficacy and self-concept, Pajares (1997) argued that if self-efficacy is measured at a domain specific level, both constructs become very similar empirically.

Effects of self-efficacy and gender differences. The self-efficacy construct has been evidenced to be useful for explaining and predicting students' motivation for learning science as well as gender differences in the choice of science. For example, Lent, Brown, and Larkin (1984, 1986) found that college students who reported higher self-efficacy for educational requirements tended to persist longer in technical/scientific programs as well as achieve higher grades than those who reported lower self-efficacy. Regarding gender differences, they found no significant differences in self-efficacy and achievement behaviors among science or technology majors. However, research findings on gender differences in ability beliefs tended to vary depending on the sample used. In a sample of high school students, Stake (2006) found that females had significantly lower confidence in science; and Hackett and Betz (1981) found that females have lower self-efficacy than their actual performance in science or math. By contrast, other studies (e.g., Hackett & Betz, 1989; Lent, Brown, & Larkin, 1984, 1986; Li & Adamson, 1995) have found no significant or big gender differences in academically advanced high school students, college students, or science majors.

A multitude of research has reported the positive roles of self beliefs in females' persistence and resiliency in math and science programs or careers (e.g., Enman & Lupart, 2000; Hackett & Betz, 1981; Hollinger, 1983; Rejskind, 1993; Zeldin & Pajares, 2000). For example, Zeldin and Pajares (2000) researched the women who chose and excelled in mathematical, scientific, and technological careers and revealed that self-efficacy beliefs help women persevere and be resilient to academic and social obstacles in the male-dominated career areas. In particular, the women in Zeldin and Pajares's (2000) research reported that learning from women role models and verbal encouragement of family members helped them develop such confidence and efficacy.

Attributions. In line with the research that has regarded self-beliefs about ability as important for achievement motivation, females' attribution patterns have been investigated for educational intervention purposes or to explain females' lower representation in science and math (e.g., Heller & Ziegler, 1996; Li & Adamson, 1995; Subotnik, 1988). Li and Adamson found significant gender differences in attributions among gifted high school students, but their finding did not explain females' suppressed achievement in math and science. Girls were more likely to attribute both success and failure in math, science, and English to effort and strategy. They seemed to perceive the role of control, responsibility, and hard work better than the boys. However, gifted boys and girls were not different in valuing ability, interest, competitiveness, and challenge-seeking in math and science although the girls were more likely to value ability in English than boys. Neither group was different in overall maladaptive motivational tendencies such as attributing failure to uncontrollable factors (i.e., lack of ability, task difficulty, and bad teaching) and negative affect and self-concept. On the other hand, according to Heller and Ziegler (1996) and Subotnik (1988), compared to males, females were more likely to attribute their successful outcomes to effort and strategy but were more likely to attribute failure to their lack of ability. The attribution of failure to lack of ability has been regarded maladaptive for future performance because of its underlying assumption of uncontrollability of performance (Weiner, 1994).

Familial Factors

The expectancy-value theory of motivation (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000) conceptualized that children's perception of parental expectations influence their self-concepts, which in turn influence their value and expectancy. In particular, Epstein (1989) elaborated family's roles to foster children's achievement motivation and maintained that home life should be organized with an emphasis on education in addition to providing affective support. She suggested positive practices for children's attitudes, performance, goals, and self-concepts, around six components of family structure: home tasks (e.g., various home activities and family discussions about school); authority (e.g., children's participation in decision making regarding familial matters as well as their own matters); reward (e.g., parents' valuing and rewarding children's school-related skills); grouping (e.g., parents' arrangement of group learning activities and support of school programs); evaluation (e.g., parents' evaluation of children with a focus on improvement based on clear, sequential, and attainable standards); and time (e.g., scheduling time with a priority on high-quality homework and learning tasks). However, empirical research on familial effects on science motivation has found not only the indirect effects but also the direct effects of family.

Background variables. Researchers have related students' background factors such as parents' education and occupation, gender, and ability to their achievement and motivation. Research findings on the effects of parents' education level have varied. For example, Sieglen and Trost (1998) found that eminent German achievers in the natural sciences tended to have parents with higher education levels than their comparison scientist group. Specifically, research has found that parents' education level influences children's science attitudes through the mediation of home resources and extra-curricular science activities (George & Kaplan, 1998); similarly parents' education level influenced children's science achievement through the mediation of aspirations for their children's education and discussions with their children about school activities (Keith et al., 1993). In contrast, Stake (2006) found no significant effect of parents' education level on high school students' science attitudes when ability was controlled for. Meanwhile, ability and previous achievement, regardless of the sources of the information, have been found to consistently predict achievement (Fehrmann, Keith, and Reimers, 1987; Keith et al., 1993) and motivation (Stake, 2006).

Encouragement and expectations. Parents' verbal encouragement and high expectations have been found influential on science career aspirations of female students and also for women's persistence in science. Mau, Domnick, and Ellsworth (1995) found a significant association between female eighth graders' aspirations for nontraditional occupations such as engineering and science careers and their perception of parental expectations. Rayman and Brett (1995) found a significant effect of parental encouragement to pursue a career in science on women's persistence in science careers. In addition, family encouragement has been found influential for high school students' science attitudes in general. According to Stake (2006), encouragement from family, teachers, and peers mediate the effects of the status variables, such as ability, gender, and parents' education level, on high school students' science attitudes to a large degree. Among the three different sources of encouragement, she found that family was the most influential on high school students' science attitudes i.e., confidence in science, interest in science careers, and 'possible self' as a scientist.

Parents' involvement. Parents affect children's science motivation and achievement in many ways. According to Ratelle, Larose, Guay, and Senécal (2005), parents' support of children's autonomous decisions to select a science program influences children's persistence in college science or technology programs via their increased perception of competence and autonomy. Additionally, they found that parental involvement in children's career choice influences children's persistence in the programs via children's increased perception of relatedness and autonomy. According to George and Kaplan (1998), parents' discussions with their children about school and class activities influence their children's science attitudes via students' engagement in extra-curricular science activities According to Fehrmann et al. (1987), high school students' perception of their parents' involvement in their academic and social lives are significantly correlated with their grades. In addition, it was found that parents can affect their eighth graders' science achievement by increasing their homework time (Keith et al., 1993). In particular, Smith and Hausafus (1998) investigated mothers' influences on minority students' science and math achievements. Mothers' negative attitudes towards their child's taking advanced science courses or the importance of understanding mathematics for future careers were associated with minority eighth graders' lower achievement in standardized life-science and math tests. However, mothers' visits to science/math exhibits or fairs with their children were positively associated with the minority students' life-science scores.

Role models. The existence of role models in the family is positive for children's science motivation and achievement (Sieglen & Trost, 1998). In this vein, few women role models following science careers are considered as putting female students at a disadvantage for their aspirations for science careers. Baker and Leary (1995) found that, in spite of the overall positive attitudes towards science of female students, only a few female students, who had a female role model in family, could associate women with science careers.

Gender Differences

Research has reported females' unfavoring science motivation: lower interest (Astin & Nichols, 1964;), lower confidence and self-efficacy (Hackett & Betz,1981; Quihuis, 2002; Stake, 2006), higher test-anxiety (Quhuis, 2002). In addition, Greene and DeBacker (2004) indicated that female students' pursuit of multiple career and life goals could disadvantage them by forcing them to withdraw from the attainment of a goal. According to Greene and DeBacker (2004), in contrast to female students, male students tend to set their major life goals in a longer time frame which results in fewer goal conflicts. However, they also noted that the traditional differences in career and life goals have decreased in the literature over the decades.

Research findings of no significant gender differences in science or math have also been published. Greene, DeBacker, Ravindran, and Krows (1999) reported no gender differences in perceived ability in elective math classes. In parallel, Eccles et al. (1983) found that females were not significantly different in expectancy for success in the current math class although they had lower expectancy for success in future math classes. In addition, female students did not differ from male students in terms of their value of high school math (Greene et al., 1999) and science (DeBacker & Nelson, 2000). In fact, a number of studies have reported females' higher scores on utility of science or math classes for their future careers (e.g., DeBacker & Nelson, 2000; Glynn, Taasoobshirazi, & Brickman, 2007). In particular, gender differences tend to be negligible among the samples composed of science majors or high school students who are aspiring towards a college science degree. Quihuis (2002) found no significant gender differences in ability beliefs, task-value, mastery goals, and test-anxiety among high-achieving high school students, who aspire toward a college degree in the hard sciences. In addition, Lent, Brown, and Larkin (1984, 1986) found no significant gender differences in self-efficacy and achievement behaviors among science and technology majors.

Disadvantages from social milieu for females' science careers. The fields of science and engineering have been stereotyped as male-dominated domains. Steele (1997) has noted that in situations where negative stereotypes on females' competence in math or in the hard sciences exist, females, in particular those who already have identified themselves with the areas, are most vulnerable to withdrawing themselves from the domain psychologically to prevent themselves from being stereotyped. The study of Smith, Sansone, and White (2007) is in line with this view. Smith and colleagues investigated the effects of competence-based stereotypes on female undergraduate students' interest in computer science tasks. Their experiments revealed that cues which imply women's lower ability in science deteriorated their interest in computer science tasks, especially for those who were achievement oriented. On the other hand, Baker and Leary (1995) investigated the negative effects of the stereotypes about science on female students' perceptions about science, science learning, science careers, and supports from peers and parents. From the interviews of second, fifth, eighth, and eleventh grade female students, the researchers found that female students rarely associated women with science careers, except for a few students who had a role model in the family. They also reported that female students tended to think more of relational values, and were concerned that such values could often be ignored in the assertive working atmosphere of scientific communities.

Positive factors for females' science aspirations. Mau et al. (1995) found female students who aspire towards science and engineering occupations and those who aspire towards traditional occupations significantly differed in their educational aspirations, perceived parental expectations, and academic performance. These factors were favorable for eighth-grade females who aspired towards nontraditional occupations. According to the authors, the effects of the factors were larger than the effect of socioeconomic status or self-concept of ability. In particular, family encouragement has been indicated as important for women's retention in a science career. In the study of Rayman and Brett (1995), female college graduates who had majored in science, math, or technology and had remained in a science career, considered parental encouragement to pursue a career in science as one of the factors that influenced their retention in science careers. Zeldin and Pajares (2000) studied women who chose and excelled in mathematical, scientific, and technological careers. The researchers found that verbal encouragement of family members and female role models helped the women develop confidence and efficacy for the career, which in turn helped them overcome the academic and social barriers they confronted in the male-dominated areas.

Cultural Differences

International achievement tests have revealed that East Asian students perform better in math and science than their counterpart American students. Specifically, regarding the math achievement gap between Asian students (i.e., Chinese and Japanese) and American students (i.e., Asian American and Caucasian American), Chen and Stevenson (1995) found a number of factors related to beliefs about education and every day lives. According to the researchers, East-Asian students tended to have lower frequency of having a job, dating, and skipping school but have greater chances of having hard-working peers. These differences in everyday lives and peer relationships significantly contributed to their observed achievement gaps on a given math test. In addition, East-Asian students' tendency to consider efforts as the most important factor to influence math performance contributed to their better performance. By contrast, American students tended to consider having a good teacher as the most important factor. However, in self-confidence and interest in math, American students, in particular Asian-American students, were the highest among the compared groups.

According to the international studies on students' achievement, such as TIMSS (Third International Mathematics and Science Study), Korean students outperform in science and math their counterparts in America; however, Korean students are lower in confidence for the subjects than

American students (Shen, 2005). Regarding Korean students' higher achievement notwithstanding their less favorable educational conditions (e.g., less educational spending, larger class size, less individualized instruction) or their lower self-concept, Kim and Park (2006) have noted Korean parents' distinctive influences on children's achievement. The researchers speculated that a strong parent-child relationship characterized by parents' sacrifice and support for their child's education and children's sense of indebtedness toward their parents provided an important momentum for Korean students' academic achievement.

The Present Study

Taken together, the literature suggests the following factors are important for students' aspirations for science: personal beliefs (e.g., value, expectancy for success and self-efficacy), goal orientations (e.g., mastery goals, learning goals, performance goals, and ego goals), affect (e.g., test-anxiety), and perception of parental support (e.g., parents' expectation, encouragement, and support of activities). In addition, the literature suggests that there are gender differences in some of these factors, and the gender differences, in turn, affect females' lower aspirations for science. In the literature, however, the effects of all these factors on science aspirations and gender differences in these factors have rarely been explored among academically advanced high school students. Therefore, I propose the following research questions:

1) How do academically advanced high school students differ in their motivation for science?

2) How do they differ in their perception of parental support for their science learning and taking science careers?

3) How do they differ in terms of their experiences with science and in their perception of their own strength for science?

4) How much do the factors either individually or in combination affect their aspirations for majoring in science, math, or engineering in college? Are there gender differences in the effects of the factors?

To investigate the first question, the motivational part of the Motivated Strategies for Learning Questionnaire (Duncan & McKeachie, 2005) was used and the following factors were measured: self-efficacy, value of science, extrinsic goals, intrinsic goals, control of learning belief, and test anxiety. The instrument was developed to measure college students' motivation for the course they are taking and has been used in the US and in some other countries (Duncan & McKeachie, 2005). The research on the instrument's validity and reliability is introduced in the instrument section of Chapter III, and the definitions of the constructs were introduced in Chapter I.

To compare the factors and experiences among the advanced students, the following comparison groups were established in line with other research with an emphasis on gender differences (e.g., Lent, Brown, and Larkin, 1986; Mau, Domnick, & Ellsworth, 1995; Quihuis, 2002): science and non-science group; male and female group; male and female science group; and female science and female non-science group. The science group consisted of the academically advanced students who aspire to majoring in science, math, or engineering in college, while the non-science group consisted of the academically advanced students who opt out of majoring in science, math, or engineering.

CHAPTER III

METHODS

Participants

Tenth grade students enrolled in three high schools in South Korea participated in the study. Two of the schools were established to educate talented students in the sciences as national leaders in the fields, and the other school was established to develop global leaders equipped with scholastic excellence, honorable character, and creativity. The schools will be designated anonymously in this paper as East High School, West High School, and South High School, respectively. The East and the West High School provide to all enrolled students advanced science and math courses and research opportunities with the supervision of university faculty or specialists. South High School provides all enrolled students with advanced courses in foreign languages and social sciences as well as an individual research course. The schools select their students based on high achievement in middle school and evidence of academic excellence provided by teacher recommendation or national competitions such as Science Olympiads. In the schools, the ratio between the number of students and teachers was 6.5:1, 6.7:1, and 8:1, respectively. All enrolled students boarded at the schools and were allowed to go home every weekend.

Three hundred and ninety-eight students turned in the parental consent form and filled out the adolescent consent form and the questionnaire. After deleting responses with missing data and multivariate outliers, however, I obtained 359 participants. Among them, 221 students were male; 135 students were female; 3 students did not designate their gender. I grouped the participants into *science group* and *non-science group* according to their response to the item that asked how much they agreed with the statement “I will major in science, math, or engineering in college.” Students who marked 1 (anchored as ‘*not at all’*) to 4 (anchored as ‘*neutral*’) were assigned to the non-science group; however students who marked 5 to 7 (anchored as '*very true of me'*) were assigned to the science group. The science group consisted of 169 males (76.7%) and 50 females (22.7%), while the non-science group consisted of 52 males (37.4) and 85 females (61.2%).

Regarding the average levels of both parents' education, the science group and the non-science group were significantly different. The fathers whose child belonged to the science group tended to have received more education than those whose child belonged to the non-science group. This was the case for the mothers, too. The parents' education levels were roughly measured by the item with three options: 1 for high school graduate; 2 for college or university graduate; 3 for completion of a graduate school. The rates of fathers and mothers who were having or had had science related careers were also higher in the science group than in the non-science group. This information was obtained by the participants' responses on the item asking father's or mother's occupation with two options: science and non-science. The gender ratios, average parents' education levels, and the ratios of parents who were engaging (or had engaged) in science related occupations are summarized in Table 1.

Among the participants who agreed to interview, six students—one male and one female from each school— were selected for a follow-up individual interview. The two students from East High School were selected by me as I could contact them (they designated their phone number on the consent form) and schedule an interview with them. The two students from West High School were selected according to their science teacher's recommendation. The teacher considered them to be cooperative and highly motivated towards science. The two students from South High School were also selected by the recommendation of their physics teacher. She told me that the students liked science very much. Each student interviewed received a book gift card amounting to ten dollars. Among the interview participants, three students reported that they would major in a science; one student reported that she would double major in a science and business; and the other two students reported that they would major in business in college. However, all participants indicated their enthusiasm and sincerity for learning science subjects.

Table 1

Sample Demographic Information

	Science Group (n = 220)		Non-Science Group (n=139)	
Gender Ratio	Male (n = 169, 76.8%)	Female (n = 50, 22.7%)	Male (n = 52, 37.4%)	Female (n = 85, 61.2%)
Father Education	M = 2.24**, SD = .61		M = 2.05**, SD = .69	
Mother Education	M = 1.95*, SD = .62		M = 1.79*, SD = .59	
Father Occupation (Science)	22%		14%	
Mother Occupation (Science)	14%		7%	
	Male Group (n = 221)		Female Group (n= 135)	
Science Aspirations	Science (n=169, 76.5%)	Non-Science (n=52, 23.5%)	Science (n=50, 37.0%)	Non-Science (n=85, 63.0%)
Father Education	M = 2.22*, SD = .64		M = 2.07*, SD = .65	
Mother Education	M = 1.94*, SD = .62		M = 1.81*, SD = .59	
Father Occupation	22%		14%	
Mother Education	13%		8%	

Note. M: average education level (M=1: high school graduate, M=2: college graduate, M=3: graduate school graduate). One student in the science group and two students in the non-science group did not identify their genders. *p < .05, 2-tailed t-test. **p < .01, 2-tailed t-test.

Instruments

In the study a questionnaire and semi-structured interviews were used to assess and understand the students' psychosocial factors related to science learning and their perceptions of parents' support for their science learning. The questionnaire included 37 seven-point Likert-type items, three open-ended questions, and demographic information. Among the Likert-type items, 31 items were adapted from the Motivated Strategies for Learning Questionnaire (MSLQ: Duncan & McKeachie, 2005); six items, five of which comprise a parental support scale and one of which measures the aspirations for science degrees, were developed by me for the current study. For Korean participants, I translated the questionnaire into Korean and have it checked by three bilingual gifted high school students and three bilingual undergraduate students. Based on their feedback, I revised the translation repeatedly. The final Korean version was completed after a couple hours of discussion with one bilingual Ph.D. in the math education department in a Research I university. This process was undertaken to ensure the equivalence of the items' meaning in both language versions. The Korean version questionnaire items used in the study and their English version are included in Appendix A.

Demographic Information

Students were asked to indicate their favorite science courses, future career, the number of science courses taken in high school, gender, parents' highest education, and parents' occupation. I provided three options for father's and mother's highest education: high school diploma, college degree, and graduate school degree. Regarding father's and mother's occupations, students were asked to indicate whether each was a science or non-science career.

Scales Adapted From the MSLQ

The MSLQ was developed by Pintrich and his colleagues to assess college students' achievement motivation and study strategies for a specific course based on a social-cognitive model of motivation (Garcia & Pintrich, 1995). Since its development, the MSLQ has been widely used in the U.S. and in foreign countries. The instrument is a seven-point Likert-type questionnaire and consists of two parts: motivation and learning strategies. However, only the motivation part that is composed of the six sub-scales (self-efficacy, control of learning belief, value, intrinsic goals, extrinsic goals, and test-anxiety) is relevant to this research, so it is the only part that was used.

Multiple researchers have reported the instrument's structural and predictive validity (e.g., Buyukozturk, Akgun, Ozkahveci, & Demirel, 2004; Davenport, 2003; Pintrich, Smith, Garcia, & McKeachie, 1993). For example, Pintrich et al. (1993) and Buyukozturk et al. (2004) conducted confirmatory factor analyses at the item level. Pintrich et al. (1993) obtained reasonable goodness of fit indices (e.g., $\chi 2/df=3.49$, RMR=.07) using a sample of 380 college students. In particular, Buyukozturk et al. obtained reasonable goodness of fit indices (e.g., $\chi 2/df=4.47$, RMSEA=.06, CFI=.82) using the instrument translated in Turkish and a sample of 852 Turkish university students. Additionally, according to Pintrich et al. (1993), they have found significant correlations between the motivation scales and final course grades except for the extrinsic goals scale ($.13 < r \leq .42$).

To adapt the MSLQ items to the current research, I modified the wording slightly by replacing the phrase "this class" and "this course" with "the course," so that the items could be related to a specific favorable science course each participant chose. In addition, I added the phrase "in the course" to every test-anxiety item so that I can measure test-anxiety involved in testing situations of a specific science course. For example, the item "When I take a test I think about how poorly I am doing compared with other students' was replaced with "When I take a test in the course I think about how poorly I am doing compared with other students." Participants were guided to check one response that was the most relevant to them among seven options. Anchors were provided: 1 (*Not at all true of me*), 2-3 (*Not true*), 4 (*Neutral*), 5-6 (*Somewhat true*), and 7 (*Absolutely true of me*).

Self-efficacy scale. This eight-item scale measures both expectancy for successful outcomes and level of confidence in mastering course contents and skills. A higher score in the scale reflects a higher level of self-efficacy. Pintrich and his colleagues have obtained robust internal consistency reliabilities of the scale, an average .93 Cronbach's alpha, across college student samples in various academic disciplinary courses (Garcia & Pintrich, 1995).

Value of science scale. This six-item scale was used to assess students' value of the science course in terms of intrinsic interest, utility, and importance. According to Garcia and Pintrich (1995), a high Cronbach's alpha, an average value of .90, has been obtained in college student samples researched by Pintrich and his colleagues.

Control of learning belief scale. This four-item scale measures the level of belief in one's own effort and appropriate strategies for understanding and learning. A higher score on the scale reflects a tendency to regard effort and appropriate strategy use rather than teaching quality or luck as causes of success in a course. According to Garcia and Pintrich (1995), however, previous studies of college students have not yielded a high internal consistency reliability. They reported an average Cronbach's alpha of .68.

Intrinsic goals scale. This four-item scale was used to assess level of endorsing mastery and learning goals. The items measure challenge-seeking behaviors (e.g., In the science course, I prefer course material that really challenges me so I can learn new things) which have been considered an outcome of learning goals (Dweck & Leggett, 1988) as well as mastery goal orientation. According to Garcia and Pintrich (1995), previous studies of college students have yielded a good internal consistency reliability, an average Cronbach's alpha of .74, in spite of the relatively small number of items.

Extrinsic goals scale. This four-item scale was used to measure the level of endorsing performance and ego goals. However, one of the items "If I can, I want to get better grades in the course than most of the other students" did not seem very relevant to the purpose of measuring extrinsic goals. This statement may reflect most students' wish rather than reflect a tendency to pursue an external reason for studying. However, I retained the item in the scale to acquire comparability with the other studies that used the MSLQ. According to Garcia and Pintrich (1995), the scale has not obtained a good internal consistency reliability from college student samples i.e., an average Cronbach's alpha of .62.

Test-anxiety scale. This five-item scale measured the level of involved distraction, concerns, negative feeling, and uneasy physiological response (i.g., fast heart beating) in science testing. A higher score in the scale reflects a higher level of test-anxiety. Pintrich and his colleagues have obtained an average Cronbach's alpha of .80 from college student samples (Garcia and Pintrich, 1995).

Parental Support Scale

For the current study, five Likert-type items were developed to assess students' perception of their parents' support for their learning and choosing science. The writing of these items was guided by previous research. The scale measured the level or frequency of perceived influence from role models in family (Baker & Leary, 1995; Sieglen & Trost, 1998); discussion with parents about children's progress in science courses (George & Kaplan, 1998; Keith et al., 1993); parents' expectation for their children's science learning (Mau et al., 1995; Smith & Hausafus, 1998); parents' encouragement to pursue science careers (Quihuis, 2002; Rayman & Brett, 1995; Stake, 2006); and parents' support for science activities (Simpkins et al., 2006). I created each item with a seven-point response option in line with the other scales adapted from the MSLQ.

Aspiration Scale

The one-item Likert-type scale was developed to measure students' aspirations for majoring in science in college: "In college, I will major in science, math, or engineering." Its response option was the same as the other scales. This item was also used to classify the participants into the science group and the non-science group. Students who chose options ranging from zero (*not at all true of me*) to four (*neutral*) were assigned to the non-science group, and students who chose options ranging from five (*somewhat true*) to seven (*Absolutely true*) were assigned to the science group.

Three Open-Ended Questions

Three open-ended questions were included to collect information on the science activities students had been engaged in, students' own thoughts on their strengths for achieving in science, and students' immediate reason for their determination or avoidance of a science major. I asked them to briefly answer the questions in one or two short sentences. The questions were expected to help me understand students' overall activities, self-concepts, and rationales for choosing science or opting out of science, which the Likert-type questions did not afford. However, the virtue of open-ended questions could be limited by "the task of writing being involved, and the lack of stimulus of a 'live' interview" (Gillham, 2000, p. 13).

Semi-Structured Interviews

The purpose of including interviews in this study was to obtain insight for the establishment and interpretation of the structural model as well as to understand the developmental processes of students' aspirations for science. Specific interview questions and their sequence were determined in advance so that the same questions are to be asked to each interviewee in a standardized manner (Patton, 2002, p. 344). Each interview started with a question asking which science subject they liked the most, which was followed by the additional request to introduce pleasant experiences they had while learning the subject. Then, additional questions were asked to identify why they like the specific subject the most; how the subject is important to them; how they study the subject; what good aspects of themselves they found while studying the subject; when they felt successful in science classes; what aspects of the subject is the most interesting; how the subject is valuable to them; what goals they have in the science classes; why they applied for the current high school; who was influential for their getting into the high school; how their parents have supported their science learning; and what extra-curricular science activities they have engaged in. Each interview concluded with questions about participants' plans after high school graduation. However, in addition to the questions, their opinions about the importance of effort over aptitude for science learning were asked of some participants. Each interview lasted about forty minutes and was recorded using a digital sound recorder. When I asked a participant about his feeling after finishing the interview, he expressed that he felt good because he had time to think about himself and to freely talk about his feelings and opinions related to his science learning. A sample of the questions used in the interviews is included in Appendix B.

Procedures

Data were collected in the beginning of June which was about three months after all the participants started their high school as freshmen. With the help of informants in each school, the parents' consent forms were distributed to all tenth grade students by their homeroom teachers. Participants were asked to take the form home and to bring back signed forms the next Monday. During the following week, I visited each school and administered the questionnaire during study hall in one school and during homeroom time after the day's classes in the other two schools. At the former school, I met the students face to face in a large study hall where all tenth grade students were studying on their own. The helping teacher introduced me to the students, and I briefly explained to them the purpose of the study and the anonymity and confidentiality of their responses. I told them not to fill out the questionnaire if their parents did not allow them to participate and asked them to write their phone numbers on the adolescent's consent form if their parents and they wanted to participate in the follow–up interview. I directed all the participants to think of a favorite science course before they started to fill out the questionnaire. While the participants were filling out the questionnaire, I went around the room and answered students' questions. After collecting signed parents' consent forms, adolescent consent forms, and filled out questionnaires, I sorted out the students who designated their phone numbers to participate in the follow-up interviews and contacted them. Based on available times, two students, one male one female were selected from the school. Individual interviews were conducted at a time convenient for each student in a counseling room with no other people during the interviews. At the latter schools, I used the intercom system to explain the purpose of the study and the anonymity and confidentiality of their responses. The students received the questionnaire and the adolescent's consent form from their homeroom teachers, and after listening to my explanation and direction over the school intercom system they filled out the adolescent's consent form and the questionnaire. While they were completing the questionnaire, I passed by each classroom and answered students' questions when requested. The interview participants from the schools were selected by their science teacher. One science teacher in each school chose one male and one female among the students who agreed to the interview based on their enthusiasm with science. The individual interviews were conducted in an English classroom or a science lab at each student's convenient time. No other people were present during the interviews.

Analyses

Statistical Analyses

The responses on the Likert-type items and demographic information in the questionnaire were compiled into an SPSS data file. Using Lisrel 8.54 and SPSS 13.0, the following statistical analyses were conducted. First, data screening: the data set was screened to leave out cases with missing variables and multivariate outliers. Kline (2005) indicated that structural equation modeling (SEM), which was used for the study, can be biased due to inclusion of multivariate outliers. Second, reliability and validity analysis: Cronbach's alpha coefficients and average inter-item correlations for seven motivational scales were calculated to examine their internal consistency reliabilities. Then, an exploratory factor analysis for the parental support scale and a confirmatory factor analysis for the whole measurement model were conducted to examine the instrument's construct validity. Third, group comparisons: to compare group differences (i.e., science vs. non-science group; male vs. female group; male science vs. female science group; female science vs. female non-science group) in the motivational factors, measurement invariance tests, comparisons of factor correlation patterns, structured means analyses, and multiple indicators multiple causes (MIMIC) modeling were applied. These statistical methods were chosen because of their capacity to allow group comparisons on latent factors whose measurement errors were accounted for. The capacity is a distinctive strength of SEM, which is not available in other methods such as MANOVA and regression (Hancock, 1997). Fourth, test of a hypothesized structural regression model: a full structural model was established and tested for its fit to the data to investigate how the factors either individually or in combination affect the aspirations for majoring in science in college. All parameters involved in these analyses and fit indexes were estimated by the Maximum Likelihood (ML) estimation method as all the variables were considered normally distributed.

Selected fit indexes. The SEM outputs provide several different fit indexes by which a hypothesized model's fit to data can be assessed. Among them the χ^2 goodness of fit statistic assesses the magnitude of discrepancy between the observed and fitted covariance matrices. However, as the value is a function of sample size, it is likely to indicate a larger discrepancy for a larger sample. To supplement the χ^2 statistic, Hu and Bentler (1999) have recommended using a combination of different fit indexes and a certain range of cutoff criteria. However, it seems that no definite rule for selecting fit indexes and cutoff criteria has been established, and even widely advocated fit indexes and cutoff criteria have limits in their function to detect misspecified models depending on the sample size, variable distributions, model complexity, and model parameters (Marsh, Hau, & Wen, 2004).

For the current study, I selected the χ^2 goodness of fit statistic, the root mean square error of approximation (RMSEA) and its 90% confidence interval, the Nonnormed Fit Index (NNFI, also known as TLI), Bentler's Comparative Fit Index (CFI), and the standardized root mean squared residual (SRMR). RMSEA and SRMR are absolute fit indexes which assess how well a hypothesized model reproduces the observed covariance matrix compared to a saturated model that exactly replicates the observed covariance matrix (Hu & Bentler, 1999). In contrast, NNFI and CFI are incremental fit indexes which measure the improved degree of a hypothesized model from a base line model or a null model in which all the variables are uncorrelated (Hu & Bentler, 1999). According to

Hu and Bentler (1998), when the ML estimation method is used, NNFI and CFI are very sensitive to complex model misspecification and are preferable for a small sample size e.g., less than 250; RMSEA is very sensitive to complex model misspecification but is less preferable for a small sample size; SRMR is moderately sensitive to complex model misspecification but is less sensitive to sample size.

As the values of χ^2 indicated a significant discrepancy of the fitted model from the data in all the entailed tests, I evaluated a model's overall fit in reference to the following cutoff criteria: .08 for RMSEA (Kline, 2005); .95 for NNFI and CFI; and .08 for SRMR (Hu & Bentler, 1999). In many cases, however, there were inconsistencies among the indication of the statistics.

Analysis of the Open Ended Questions

I summarized students' responses on the three open ended questions using Excel. The responses on each question fell into several categories, and some responses corresponded to more than one category. I tallied the frequencies of each category. Then, the response patterns were contrasted across each pair of comparison groups: science and non-science group; male and female group; female and male science group: and female science and female non-science group. The process yielded an effective description of the main activities in which students had participated, the overlapping self-concept of strength for science learning, and the prevalent reasons for choosing or opting out of science.

Analysis of Interview Data

Six interviews were transcribed verbatim in Korean. For analysis, I repeatedly read one student's transcription and highlighted substantive statements. Then, the statements were categorized according to their underlying factors. The process was repeated for the other students' interview transcriptions one by one. When a substantive statement that did not fit any one of the categories was found, a new category was created. Subsequently, guided by my research questions, the categories were grouped into several topics: interest in science; self-efficacy; value of science; influential people; parental support; visions of science. Under these headings, corresponding quotations were listed in Korean, along with my interpretations. Finally, the Korean quotations were translated with the help of a bilingual undergraduate senior who was majoring in physics and mathematics.

The interviewing study has some limitations because the interviews were conducted in a relatively short time period and in a structured manner, which hindered eliciting students' own terms and delving into the meanings implied by the terms. However, I believe that the interview study helped me understand the details of advanced students' beliefs and actions involved in their science learning and career planning in the context of South Korea. Additionally, I believe that the findings can serve as a useful reference for further research that aims to understand the science aspirations of advanced students living in other countries as well as in South Korea.

CHAPTER IV

STATISTICAL ANALYSES

Data Screening

Among the total 398 responses, nineteen responses included missing variables, so they were deleted. All 37 Likert-type items included in the remaining 379 responses were univariate normal as evidenced by each item's skewness whose absolute value was less than 2 and by each item's kurtosis whose absolute value was less than 4. I calculated the Mahalanobis distance of each case through the regression procedure provided by the SPSS program and detected 20 multivariate outliers according to the criteria 'critical F (.05/n) = 72.80' obtained by the SPSS DeCarlo normtest (DeCarlo, 1997, p. 302). As multivariate outliers can bias the estimations in SEM (Kline, 2005), I deleted the 20 outliers and kept 359 cases in the data set. The resulting relative multivariate kurtosis 1.115 supported the multivariate normality of the responses.

Reliability

First, the item property of the parental support scale was examined. The SPSS program provided the resultant Cronbach's alpha when each target item was deleted, and it also provided the scale's inter-item correlation matrix. The output indicated that one item (i.e., I have been influenced greatly in my science learning from a role model in my family.) did not correlate with the other items substantively (.160 < inter-item correlations < .343), and alpha would be improved from .768 to .809 if the item were deleted. Therefore, I deleted the variable from the parental support scale.

Next, to examine how much each scale measured its target construct consistently, I calculated the average inter-item correlation as well as the internal consistency reliability coefficient for each scale. Clark and Watson (1995) argued that an average inter-item correlation was a more stable coefficient to indicate the degree to which the scale items measured their target construct than

Cronbach's alpha whose value must be influenced by the number of items in the scale. The obtained coefficients for the seven motivational factors are summarized in Table 2.

Table 2

Reliability Analysis: Cronbach's Alphas and Average Internal Correlations

Scale	Self-efficacy	Value of Science	Extrinsic goals	Intrinsic goals	Control of Learning	Test-anxiety	Parental support
# of items	8	6	4	4	4	5	4
Cronbach's α	.902	.835	.543	.675	.600	.552	.809
Average internal correlations	.541	.466	.241	.348	.293	.194	.519

Overall, the Cronbach's alpha coefficients for each MSLQ scale were relatively lower than those reported in Garcia and Pintrich (1995). The self-efficacy, value, and parental support scale yielded a great or good internal consistency reliability; however, the other four scales yielded a low alpha (Kline, 2005). Nonetheless, the four scales' average inter-item correlations indicated that their reliabilities were still acceptable. Clark and Watson (1995) suggested that average inter-item correlation as low as .15-.20 could probably be desirable for "a broad higher order construct" (p. 316). In particular, extrinsic goals and test-anxiety yielded quite a low alpha and an average internal correlation. The extrinsic goals scale actually measures two distinctive constructs, performance goal orientation and ego goal orientation. The lower average internal correlation seems to reflect the multi-dimensionality of the scale besides the small number of items included in the scale. Among the test-anxiety items, one item ("When I take a test in the course, I think about the items on other parts of the test I can't answer") seems very problematic as indicated by its negligible correlations with other test-anxiety items (e.g., r = .003 and .080). Rather than reflecting anxiety, it may reflect advanced students' attitude toward correctly answering all the given problems in a test. Its high mean value, 5.15, seems to support that. The observed covariance matrix, means, and standard deviations of the thirty-five variables for the whole sample are reported in Appendix C.

Validity

Exploratory factor analysis. Before I tested the fit of the measurement model used to the current data, I conducted an exploratory factor analysis (EFA) of the parental support scale to check whether the scale was unidimensional. I executed principal axis factoring without rotation. The scree plot and eigenvalues > 1 criteria suggested a one-factor structure. The factor explained 52.355% of the total variance. Individual items' factor loadings are summarized in Table 3. The items seemed to appropriately measure the parental support factor.

Confirmatory factor analysis. As previously mentioned, the MSLQ has been widely used, and its validity has been evidenced by several studies with college student samples in different countries. In this study, I did not conduct EFA for the six scales adapted from the MSLQ but conducted a confirmatory factor analysis (CFA) of the whole seven-factor scale using the Lisrel 8.54 program and ML estimation. Its purpose was to acquire evidence of the structural validity of the instrument.

In the CFA, every item was set to load on only its target factor; all measurement error covariances were set to zero, but all latent factors were set to freely correlate. In scaling the latent factors, I used the Unit Variance Identification (UVI) (Kline, 2005). Selected fit indexes indicated a lack of model fit to the data: χ^2 (df = 539) = 1720.469 (p=0.0), RMSEA = .081; 90% confidence interval for RMSEA = (.077; .085); NNFI = .93; CFI = .93; SRMR = .11. Modification Indices (MI) suggested many double loadings and covarying measurement errors.

Table 3

Factor Loadings of Parental Support Items

Item	Unstandardized Factor Loading
My parents expect me to achieve high grades in the science courses.	.627
My parents often discuss with me my progress in the science courses.	.723
My parents have strongly encouraged me to have a science career in the future.	.780
My parents have sincerely supported my participation in science extracurricular activities.	.755

To improve the model fit, I allowed error covariances to be estimated freely for three pairs of items, whose wordings were quite similar in the Korean version. The items are as follows: *It is important for me to learn the course material in the course, and Understanding the subject matter of the course is very important to me; I'm certain I can understand the most difficult material presented in the readings for the course, and I'm confident I can understand the most complex material presented by the teacher in the course; It is my own fault if I don't learn the material in the course, and If I don't understand the course material, it is because I didn't try hard enough.* I assumed that the redundant items must involve some common sources of error. The CFA output supported the assumption: the three error covariances were statistically significant (i.e., t = 5.57, 7.42, and 6.05, respectively). The Simplis syntax used is included in Appendix H. The selected goodness of fit indexes were as followes: χ^2 (df = 536) = 1554.84 (p=0.0), RMSEA = .074; 90% confidence interval for RMSEA = (.069; .078); NNFI = .94; CFI = .94; SRMR = .11. As presented in Table 4, these fit indexes indicated an improved model fit. Most fit indexes approached the cutoff values recommended by Hu and Bentler (1998) and, in particular, the root mean squared error of approximation (RMSEA) and its 90% confidence interval (CI) indicated the measurement model was acceptable. The relatively poor fit was expected, given the measurement model that constrained each variable to load on only the designated factor. For an instrument that measures psychological constructs, that constraint is usually unrealistic and renders poor model fits.

Table 4

Fit Indexes of Measurement Model

Preliminary Measurement Model		Modified Measurement Model	
Statistic	Value	Statistic	Value
χ^2/df	χ^2(539) =1720.469 1720.469/539 =3.2 (p = 0.0)	χ^2/df	χ^2(536) =1554.84 1554.84/536 = 2.9 (p = 0.0)
RMSEA 90% CI	.081 (.077; .085)	RMSEA 90% CI	.074 (.069; .078)
NNFI	.93	NNFI	.94
CFI	.93	CFI	.94
SRMR	.106	SRMR	.106

The unstandardized and standardized factor loadings, standard errors, and explained variances (R^2) estimated using UVI identification are summarized in Table 5. Another CFA with ULI identification yielded the same standardized factor loadings, error variances, and R^2, but yielded quite different estimations of standard errors and subsequent t values (Gonzalez & Griffin, 2001). However, each loading's statistical significance was unaffected by the difference in standard errors. All factor loadings had appropriate sign and significant magnitude. All standardized factor loadings were substantive ranging from .17 to .88. R^2 values ranged from .11 to .77 except for two items, cl2 included in the control of learning subscale (R^2 = .072) and ta2 included in the test-anxiety subscale (R^2 = .027).

Table 5

ML Estimations for Measurement Model Based on Unit Variance Identification

	Item	Factor Loading	SE	Standardized Factor Loading	R^2
se1	I believe I will receive an excellent grade in the course.	.87	.054	.74	.55
se2	I'm certain I can understand the most difficult material presented in the readings for the course.	.97	.065	.71	.50
se3	I'm confident I can learn the basic concepts taught in the course.	.53	.046	.58	.34
se4	I'm confident I can understand the most complex material presented by the teacher in the course.	1.06	.067	.74	.54
se5	I'm confident I can do an excellent job on the assignments and tests in the course.	.95	.051	.82	.68
se6	I expect to do well in the course.	.99	.050	.86	.74
se7	I'm certain I can master the skills being taught in the course.	.76	.066	.58	.34
se8	Considering the difficulty of the course, the teacher and my skills, I think I will do well in the course.	.94	.050	.83	.68
tv1	I think I will be able to use what I learn in the course in other courses.	.55	.065	.44	.19
tv2	It is important for me to learn the course material in the course.	.70	.057	.61	.38
tv3	I am very interested in the content area of the course.	.99	.048	.88	.77
tv4	I think the course material in the class is useful for me to learn.	.73	.053	.66	.44
tv5	I like the subject matter of the course.	.84	.047	.80	.64
tv6	Understanding the subject matter of the course is very important to me.	.74	.054	.66	.43
eg1	Getting a good grade in the course is the most satisfying thing for me right now.	.91	.098	.59	.35
eg2	The most important thing for me right now is improving my overall grade point average, so my main concern in the course is getting a good grade.	.82	.094	.55	.30

eg3	If I can, I want to get better grades in the course than most of the other students.	.26	.043	.39	.15
eg4	I want to do well in the course because it is important to show my ability to my family, friends, or others.	.75	.10	.47	.22
ig1	In the science course, I prefer course material that really challenges me so I can learn new things.	.81	.056	.70	.49
ig2	In a course like it, I prefer course material that arouses my curiosity, even if it is difficult to learn.	.94	.058	.77	.60
ig3	The most satisfying thing for me in the course is trying to understand the content as thoroughly as possible.	.50	.062	.43	.19
ig4	When I have the opportunity in the course, I choose course assignments that I can learn from even if they don't guarantee a good grade.	.76	.077	.52	.27
cl1	If I study in appropriate ways, then I will be able to learn the material in the course.	.47	.043	.59	.34
cl2	It is my own fault if I don't learn the material in the course.	.37	.080	.27	.072
cl3	If I try hard enough, then I will understand the course material.	.71	.045	.83	.69
cl4	If I don't understand the course material, it is because I didn't try hard enough.	.47	.067	.39	.15
ta1	When I take a test in the course I think about how poorly I am doing compared with other students.	.95	.11	.54	.30
ta2	When I take a test in the course I think about items on other parts of the test I can't answer.	.20	.078	.17	.027
ta3	When I take tests in the course, I think of the consequences of failing.	.54	.10	.33	.11
ta4	I have an uneasy, upset feeling when I take an exam in the course.	1.00	.097	.64	.41
ta5	I feel my heart beating fast when I take an exam in the course.	.77	.10	.48	.23
ps1	My parents expect me to achieve high grades in the science courses.	.90	.070	.66	.44
ps2	My parents often discuss with me my progress in the science courses.	1.15	.080	.72	.52
ps3	My parents have strongly encouraged me to have a science career in the future.	1.48	.094	.77	.59
ps4	My parents have sincerely supported my participation in science extracurricular activities.	1.42	.093	.75	.56

Note. The two letter codes included in the first column indicate the item's target factor—se: self-efficacy, tv: value of science, eg: extrinsic goals, ig: intrinsic goals, cl: control of learning belief, ta: test-anxiety, and pa: parental support.

Factor correlations. The CFA yielded a correlation matrix for seven latent factors, which is reported in Table 6. Consistent with research findings, a large positive correlation between self-efficacy and value of science (Pintrich & De Groot, 1990); a negative correlation between test-anxiety and self-efficacy (Meece et al., 1990; Pintrich & De Groot, 1990); and a negative but non-significant relationship between test-anxiety and value of science (Pintrich & De Groot, 1990) were found. A small correlation between intrinsic goals and extrinsic goals seemed to evidence the discriminant validity of the measures. However, the large correlation between value of science and intrinsic goals which exceeded .9 suggested a lack of discriminant validity of the measures or a multicollinearity problem. Except for that, the other correlations seemed to reflect appropriate relationships among the motivational constructs.

Table 6

Factor Correlation Matrix for the Whole Sample

	Self-Efficacy	Value of Science	Extrinsic Goals	Intrinsic Goals	Control of Learning	Test-Anxiety
Value of Science	.76**					
Extrinsic Goals	.29**	.28**				
Intrinsic Goals	.71**	.91**	.21**			
Control of Learning	.70**	.73**	.21**	.77**		
Test-Anxiety	-.27**	-.03	.51**	-.03	-.06	
Parental Support	.47**	.51**	.42**	.47**	.26**	.20**

Note. **$p < .01$.

Comparisons Between the Science Group and the Non-Science Group

To compare differences in the motivational factors between academically advanced students who aspire towards science (science group, n = 220) and those who do not (non-science group, n = 139), multiple-group structural equation modeling was used. Multiple-group SEM is advantageous to a multivariate analysis of variance (MANOVA) for the comparison of factor means. The former method takes into account of measurement errors involved in the measurement of variables and also measurement bias between groups in one or more measured variables by the capacity to designate unequal intercepts (Thompson & Green, 2006). As a result, the former approach renders comparisons of error-free latent constructs, yielding greater power than the latter approaches in detecting group differences in latent variable means (Thomson & Green, 2006). However, given the complicated measurement structure but comparatively small number of observations, the use of a multiple-sample SEM approach in the current study was susceptible to the danger of unstable parameter estimation. The problem limits generalization of all findings from forthcoming analyses.

Tests of measurement invariance. For a proper comparison of latent construct means between different groups, the test used need to be reasonably invariant across the groups, so that group membership does not affect the relation between a set of indicators and its specified construct in the measurement model (Kline, 2005, p. 295). Tests of measurement invariance in SEM usually entail a series of sequential multiple-sample CFA or hierarchical tests varying in the extent of equality constraints imposed on the groups: a test of configural invariance (the equivalence of factor structure across different groups), a test of metric invariance (the equivalence of each indicator's factor loading across different groups), and a test of scalar invariance (the equivalence of each item's intercept across different groups) (Kline, 2005).

The testing procedures are as follows. A reasonably acceptable configural invariance model serves as the baseline model. Then, additional equality constraints are imposed on the baseline model sequentially, and a chi-square difference test is conducted to evaluate whether the imposed constraints significantly worsen model fit compared to the preceding model. If the chi-square difference test is nonsignificant, the additional invariance is supported. The Simplis syntaxes used in this analysis are all listed in Appendix I.

One-group CFA. Before conducting a series of measurement invariance tests, I examined fit of the measurement model to each science group and non-science group by conducting one-group CFA. Consistent with the overall measurement model, I allowed the error covariances between se2 and se4, tv2 and tv6, and cl2 and cl4 to be freely estimated in each group. The CFA outputs supported the decision. All covariances were statistically significant in both groups: t = 6.87, 4.10, and 4.82, respectively in the science group; t = 2.51, 3.87, and 3.70, respectively in the non-science group. Among the selected fit indexes reported in Table 7, the RMSEA indicated the measurement model fit the science group reasonably well. For the non-science group, the fit indexes approached reasonable fit.

Table 7

Fit Indexes From One-Group CFA (Science Group and Non-Science Group)

	χ^2 (df)	RMSEA 90% CI	NNFI	CFI	SRMR
Science Group (n=220)	1152.11 (536) χ^2/df = 2.1 (p=0.0)	.073 (.067; .079)	.91	.92	.100
Non-Science Group (n=139)	1093.91 (536) χ^2/df = 2.0 (p=0.0)	.076 (.068; .083)	.90	.91	.126

Test of configural invariance. In this test, the model is implicitly specified to have zero loadings on nontarget factors, but equality constraints are not imposed on salient factor loadings

(Steenkamp & Baumgartner, 1998). For the test, as in other invariance tests, ULI (Unit Loading Identification) should be applied in scaling latent factors (Kline, 2005), which precludes unintentional imposition of equal factor variances across groups. The other parameters such as intercepts, factor loadings, error variances, and factor variances and covariances are freely estimated across groups.

Besides those specifications, I let the error covariances between se2 and se4, tv2 and tv6, and cl2 and cl4 be freely estimated, to be consistent with the one group CFA model. Yielded global goodness of fit indexes were as follows: χ^2 (df = 1072) = 2246.021 (p=0.0), RMSEA = .074; 90% confidence interval for RMSEA = (.069; .079); NNFI = .91; CFI = .91, SRMR = .13. Global goodness of fit indexes represent a total lack of fit in the groups. The value of the minimum fit function chi-square and the incremental fit indexes indicated that the model did not fit well; however, the RMSEA and its 90% confidence interval indicated the measurement structure was reasonably invariant across the science and the non-science group. Thus, I regarded the configural invariance model as the baseline model against which more stringent invariance model would be evaluated.

Test of metric invariance. Metric invariance refers to the concept of equal metrics or scale intervals across different groups. If an item satisfies the condition, score difference on the item across different groups can be interpreted as similar group difference in the underlying construct (Steenkamp & Baumgartner, 1998).

For the test, I imposed on the scalar invariance model additional constraints that each item's factor loading is the same across the groups. The test yielded the following global goodness of fit indexes: χ^2 (df = 1100) = 2288.675 (p=0.0), RMSEA = .074; 90% confidence interval for RMSEA = (.069; .078); NNFI = .91; CFI = .91; SRMR = .13. The fit indexes did not worsen appreciably, except for the value of minimum fit function chi-square. However, subsequent chi-square difference test indicated that this model significantly deteriorated compared to the configural invariance model: $\Delta\chi^2$ /Δdf = (2288.66-2246.02)/(1100-1072) = 42.65/28 (p < .05). Guided by the results of one-group CFA and previous analysis, I modified the model by loosening the equal factor loading constraint on tv4. The modified model yielded the following fit indexes: χ^2 (df = 1099) = 2276.53 (p=0.0), RMSEA = .073; 90% confidence interval for RMSEA = (.069; .078); NNFI = .91; CFI = .91; SRMR = .13. The fit indexes indicated an improved model fit, and the subsequent chi-square difference test indicated that the modified metric invariance model was not significantly different from the configural invariance model in model fit: $\Delta\chi^2 / \Delta df$ = (2276.53-2246.02)/(1099-1072) = 30.51/27 (p > .10). Thus, it was supported that all the measurement items except for tv4 measured their target motivational factors to the reasonably same degree in both science and non-science group.

Test of scalar invariance. This test addresses the problem of biased measurement. Even though the covariation between an observed score and its latent construct is equivalent across different groups, the groups can still be systematically upward or downward in observed scores, which renders it meaningless to compare factor means across the groups (Steenkamp & Baumgartner, 1998). For this test, equality constraints are additionally imposed on the intercepts of the invariant factor loadings. Each intercept represents the predicted value of the specified indicator when the indicator's target factor has the mean value (in CFA, all factor means are set to zero). If a chi-square difference test indicates that a scalar invariance model's fit is significantly worse than its preceding metric invariance model, the measurement model is considered to be biased even though the indicators measure their target factors to a same degree across groups.

I imposed on the partial metric invariance model the additional constraints so that the intercept of each item except for tv4 is the same across the groups. The subsequent analysis yielded the following fit indexes: χ^2 (df = 1133) = 2547.12 (p=0.0), RMSEA = .078; 90% confidence interval for RMSEA = (.074; .083); NNFI = .89; CFI = .90; SRMR = .13. Overall, the indexes indicated a deteriorated model fit. The follow-up chi-square difference test also indicated that: $\Delta\chi^2 / \Delta df$ = (2547.12-2276.53) / (1133-1099) = 270.588/34 (p < .005). To secure partial scalar invariance, I modified the model by loosening the equality constraints on the intercepts one by one guided by the

MIs, and finally obtained the following fit indexes: χ^2 (df = 1129) = 2430.64 (p=0.0), RMSEA = .076; 90% confidence interval for RMSEA = (.071; .080); NNFI = .90; CFI = .91, SRMR = .13. The freely estimated intercepts across the groups were those for ps3, ps4, tv2, and ps1, and their MIs were 29.1, 26.0, 9.6, and 9.1, respectively. The subsequent chi-square difference test indicated that the increase in chi-square value relative to the partial metric invariance model was significant: $\Delta\chi^2 / \Delta df$ = (2430.64-2276.53) / (1129-1099) = 154.11/30 (p < .001). In spite of the deteriorated χ^2 difference, RMSEA was still acceptable (< .08), and SRMR did not change. Therefore, I concluded that the partial scalar invariance model including five varying intercepts, one varying factor loading, and three measurement error covariances was acceptable for the science and non-science groups.

Table 8

Fit Indexes for Measurement Invariance Tests (Science Group and Non-Science Group)

	Test of Configural Invariance	Test of Metric Invariance	Test of Scalar Invariance
χ^2	2246.021	2276.53	2430.64
df	1072	1099	1129
RMSEA 90% CI	.074 (.069; .079)	.073 (.069; .078)	.076 (.071; .080)
CFA	.91	.91	.90
NNFI	.91	.91	.91
SRMR	.126	.132	.132

Differences in motivational factor means across the science group and the non-science group. Based on the established partial scalar invariance of the measurement model, I specified a measurement model with mean structures and compared factor means across the groups. For model specification, I fixed the means of all motivational factors to zero in the science group, so that I would obtain mean factor differences between the groups in reference to the science group.

Selected goodness of fit indexes from the measurement model with mean structures were as follows: χ^2 (df = 1120) = 2341.97 (p=0.0); RMSEA = .074; 90% confidence interval for RMSEA = (.069; .078); NNFI = .91; CFI = .91; SRMR = .13. The RMSEA and its 90% confidence interval indicated that the model was reasonably acceptable. Obtained group mean differences on the motivational factors and factor variances and their standard errors are summarized in Table 9. The standardized mean differences included in the Table 9 were calculated as follows:

standardized mean difference = sample mean difference / (within groups pooled variance estimate)$^{1/2}$

$$= [\kappa 1 - \kappa 2] / [(n_1\varphi_1 + n_2\varphi_2) / (n_1 + n_2)]^{1/2}$$ (Hancock, 2001).

Overall, the differences in factor means between the science and the non-science group were vivid. According to the Wald z test provided by the Lisrel 8.54, the non-science group's factor means were significantly lower ($p < .01$) on all the factors except for the test-anxiety. The non-science group was lower in test-anxiety, but the difference did not reach a statistical significant ($p \approx .10$). The standardized mean differences indicated that the group mean differences were large for value of science, intrinsic goals, and perception of parental support; medium to large for self-efficacy and extrinsic goals; and rather small for control of learning belief and test-anxiety. In particular, non-science students' perception of parental support was lower as much as 1.3 standard deviations than science students' perception of parental support. Even though it is common sense that academically advanced students must be motivated toward learning, this finding apparently supports the assertion that motivation varies according to subject matters or academic courses.

Table 9

Factor Mean Differences and Variances (Science and Non-Science Group)

	Science Group (n=220)		Non-Science Group (n=139)		
Means	Unstandardized	SE	Unstandardized	SE	Standardized Mean Difference
Self-Efficacy	0	-	-.58**	.10	-.72
Task-Value	0	-	-.60**	.10	-.88
Extrinsic Goals	0	-	-.48**	.12	-.68
Intrinsic Goals	0	-	-.61**	.11	-.81
Control of Learning	0	-	-.18**	.06	-.39
Test-Anxiety	0	-	-.12	.08	-.22
Parents' Support	0	-	-.95**	.17	-1.29
Factor Variances	Unstandardized	SE	Unstandardized		SE
Self-Efficacy	.60**	.09	.80**		.13
Task-Value	.27**	.05	.78**		.14
Extrinsic Goals	.46**	.13	.63**		.20
Intrinsic Goals	.44**	.08	.77**		.15
Control of Learning	.19**	.04	.26**		.06
Test-Anxiety	.31**	.12	.30*		.12
Parents' Support	.49**	.10	.62**		.15

Note. *p < .05. **p < .01.

Differences in factor correlations across the science group and the non-science group. To compare group differences in correlational relationships among the latent motivational factors, the within group completely standardized correlation matrices were examined. The correlations accounted for measurement errors. Table 10 presents the matrices.

Table 10

Factor Correlations Within the Science Group and the Non-Science Group (Within Group Completely Standardized Solution)

	Science Group						Non-Science Group					
	SE	TV	EG	IG	CL	TA	SE	TV	EG	IG	CL	TA
TV	.75						.73					
EG	.17	.17					.24	.15				
IG	.66	.88	.02				.72	.89	.20			
CL	.79	.79	.09	.75			.59	.68	.23	.76		
TA	-.21	.10	.49	-.03	-.08		-.43	-.18	.59	-.10	-.11	
PS	.43	.34	.38	.37	.31	.31	.32	.36	.22	.30	.05	.04

Note. SE: self-efficacy, TV: task-value, EG: extrinsic goals, IG: intrinsic goals, CL: control of learning belief, TA: test-anxiety, PS: parental support.

Overall, a big difference in the patterns of correlations between the groups was not found. In both the science and non-science groups, self-efficacy, value of science, intrinsic goals, and control of learning beliefs (beliefs in effort and strategy use for understanding) were correlated with one another to a large degree. In particular, the very high correlations between value of science and intrinsic goals (.88 and .89, respectively) suggested a lack of differentiation. For both groups, test-anxiety was positively correlated with extrinsic goals to a large degree. However, test-anxiety was negatively correlated with self-efficacy to a small to medium degree for the science group and to a rather large degree for non-science group. Students' perception of parental support was associated with all the other factors to a moderate degree for the science group. However, for the non-science group, students' perception of parental support had no relationship with control of learning belief or test-anxiety.

Summary of the differences between the science group and the non-science group. Overall, the science group was higher in the levels of all the examined factors. The mean factor differences were large for perception of parental support, value of science, and intrinsic goals; medium to large for self-efficacy and extrinsic goals; and rather small for control of learning belief and test-anxiety. However, the group difference in test-anxiety did not reach statistical significance. Notably, science students were less variable in all of the factors except for test-anxiety as evidenced by the science group's smaller variances and standard errors than those of the non-science group. Thus, advanced students who aspired toward a science degree seemed to be more similar in their motivational patterns than their counterparts, although both groups were rather homogeneous regarding test-anxiety. In particular, the difference in variability between the groups was very large for value of science, intrinsic goals, and self-efficacy.

Gender Differences Among Academically Advanced High School Students

In line with the analysis of differences between the science group and the non-science group, multiple-sample SEM was used to compare the motivational factor means and their relationships between male (n=221) and female (n=135) advanced high school student group. To begin with, one-group CFA and a series of measurement invariance tests—test of configural invariance, test of metric invariance, and test of scalar invariance— were sequentially conducted along with chi-square difference tests to establish the evidence that the questionnaire items measured their target factors in a reasonably same way across male and female group. The Simplis syntaxes used are listed in Appendix J.

One-group CFA. This analysis was conducted to check if the measurement model fit to each group reasonably well. Without a certain degree of confidence in the measurement model for individual group, the imposition of equal parameter constraints on the groups would be meaningless.

Consistent with the overall measurement model, I allowed the error covariances between se2 and se4, tv2 and tv6, and cl2 and cl4 to be freely estimated in each group. The CFA outputs supported the decision. All covariances were statistically significant in both groups: t = 5.76, 4.47, and 4.63, respectively in the male group; t = 4.52, 3.87, and 3.90, respectively in the female group. Selected fit indexes indicated the measurement model did not fit each group very well but approached acceptable fit. They are reported in Table 11. Estimated factor loadings and error variances did not look appreciably different across the groups for self-efficacy, intrinsic goals, and parental support scales, but it was not the case for the other scales. However, to establish the extent of partial measurement invariance (Kline, 2005, p. 295), I proceeded with invariance tests.

Table 11

Fit Indexes for One-Group CFA (Male Group and Female Group)

	χ^2 (df)	RMSEA 90% CI	NNFI	CFI	SRMR
Male Group (n=221)	χ^2 (536) = 1211.02 χ^2/df = 2.3 (p=0.0)	.076 (.070; .081)	.92	.92	.10
Female Group (n=135)	χ^2 (536) = 1020.68 χ^2/df = 1.9 (p=0.0)	.078 (.070; .085)	.93	.94	.13

Test of configural invariance. In this test, the equivalence of measurement structure across male and female groups was examined. The model was specified to freely estimate the intercepts, factor loadings, error variances, and factor variances and covariances across the groups. Consistent with the one group CFA model, I let the error covariances between se2 and se4, tv2 and tv6, and cl2 and cl4 be freely estimated. Selected global goodness of fit indexes yielded by the test were as follows: χ^2 (df = 1072) = 2231.70 (p=0.0), RMSEA = .076; 90% CI for RMSEA = (.072; .081); NNFI = .92; CFI = .93; SRMR = .13. These values indicated the measurement structure was marginally invariant across the male and the female group. The configural invariance model served as the baseline model against which a more stringent invariance model would be evaluated by a chi-square difference test.

Test of metric invariance. For this test, equal factor loading constraint was additionally imposed to the configural invariance model to examine if the measurement items measured their target factors to a same degree in both groups. Selected global goodness of fit indexes were as follows: χ^2 (df = 1100) = 2290.810 (p=0.0), RMSEA = .077; 90% confidence interval for RMSEA = (.072; .081); NNFI = .92; CFI = .93; SRMR = .14. The fit indexes did not worsen appreciably, except for the value of minimum fit function chi-square. However, the subsequent chi-square difference test was significant: $\Delta\chi^2 / \Delta df$ = (2290.81-2231.70)/(1100-1072) = 59.11/28 (p < .001). Guided by the modification indices (MI), I modified the model by loosening the equal factor loading constraints on tv4 and tv1 one at a time. Accordingly, the resultant fit indexes indicated an improved model fit: χ^2 (df = 1098) = 2265.37 (p=0.0), RMSEA = .075; 90% confidence interval for RMSEA = (.071; .080); NNFI = .92; CFI = .93; SRMR = .14. Subsequent chi-square difference test was nonsignificant: $\Delta\chi^2 / \Delta df$ = (2265.37-2231.70)/(1098-1072) = 33.67/26 (p > .10). The test supported that all the measurement items except for tv1 and tv4 measured their target motivational factors to a reasonably similar degree in both male and female group.

Test of scalar invariance. For this test, I imposed equality constraints on the intercepts of the invariant factor loadings. The test yielded deteriorated global fit indexes: χ^2 (df = 1131) = 2376.33 (p=0.0), RMSEA = .077; 90% CI for RMSEA = (.073; .081); NNFI = .92; CFI = .92; SRMR = .14. The subsequent chi-square difference test was also significant: $\Delta\chi^2 / \Delta df$ = (2376.33-2265.37) / (1131-1098) = 110.96/33 (p < .001). To secure partial scalar invariance, I modified the model by loosening equal intercept constraints on three items ps4, ig3, and se7 consecutively, guided by modification indices 12.0, 11.9, and 8.6, respectively. The resulting fit indexes were as follows: χ^2 (df = 1128) = 2340.23 (p=0.0), RMSEA = .076; 90% CI for RMSEA = (.071; .080); NNFI = .92; CFI = .93; SRMR = .14. Again, subsequent chi-square difference test indicated that the increase in chi-square value relative to the partial metric invariance model was still significant: $\Delta\chi^2$ /Δdf = (2340.23-2265.37) / (1128-1098) = 74.86/30 (p < .001). Nonetheless, the RMSEA (< .80) and CFI indicated that the overall fit of the partial scalar invariance model was reasonably acceptable.

Table 12

Fit Indexes for Measurement Invariance Tests (Male Group and Female Group)

	Test of Configural Invariance	Test of Metric Invariance	Test of Scalar Invariance
χ^2	2231.70	2265.37	2340.23
df	1072	1098	1128
RMSEA 90% CI	.076 (.072; .081)	.075 (.071; .080)	.076 (.071; .080)
NNFI	.92	.92	.92
CFI	.93	.93	.93
SRMR	.13	.14	.14

Gender differences in motivational factor means. The established partial invariance of the measurement model renders a comparison of group means on motivational factors meaningful (Kline, 2005). To compare factor means, I used Sörböm's strategy (as cited in Kline, 2005) to identify mean structures of the measurement model. First, I fixed the means of all motivational factors to zero in the male group. Then, I let the means of all factors be freely estimated in the female group so that the values should represent the relative differences on the factors. Thus the male group served as the reference group.

Selected goodness of fit indexes from the tested measurement model with mean structures were as follows: χ^2 (df = 1121) = 2295.197 (p=0.0); RMSEA = .075; 90% CI for RMSEA = (.070; .079); NNFI = .92; CFI = .93. The RMSEA and its 90% confidence interval indicated that the model was reasonably acceptable. Obtained group mean differences on the motivational factors and factor variances and their standard errors are summarized in Table 13.

Overall, advanced female students reported lower motivation for science learning, although the gender differences in factor means were not as conspicuous as between the science and the non-science group. According to the provided Wald z test (Thompson & Green, 2006) by the Simplis output, the mean differences were statistically significant ($p < .01$) on four factors. Namely, female students reported significantly lower self-efficacy, value of science, intrinsic goals, and perception of parental support. The standardized mean differences in the factors, computed by dividing each factor mean difference with square root of within groups pooled variance estimate (Hancock, 2001), were moderate, about a half standard deviation. Female students tended to endorse extrinsic goals less than male students did, although the difference did not reach statistical significance ($p \approx .10$). However, the groups' differences in control of learning belief and test-anxiety were not statistically significant or substantive. They seemed to share a common belief in the importance of strategies and efforts for understanding in science courses; and a similar level of anxiety in science tests.

Gender differences in factor correlations. To compare group differences in correlational relationships among the latent motivational factors, the within group completely standardized correlation matrices were examined. The correlations accounted for measurement errors. Table 14 presents the matrices.

Table 13.

Factor Mean Differences and Variances (Male Group and Female Group)

	Males (n=221)		Females (n=135)		
Means	Unstandardized	SE	Unstandardized	SE	Standardized Mean Differences
Self-Efficacy	0	-	-.45**	.10	-.54
Value of Science	0	-	-.34**	.09	-.48
Extrinsic Goals	0	-	-.18	.11	-.24
Intrinsic Goals	0	-	-.54**	.11	-.70
Control of Learning	0	-	-.05	.06	-.11
Test-Anxiety	0	-	.02	.07	.04
Parents' Support	0	-	-.56**	.12	-.64
Factor Variances	Unstandardized	SE	Unstandardized		SE
Self-Efficacy	.65**	.09	.80**		.13
Task-Value	.35**	.06	.75**		.14
Extrinsic Goals	.51**	.15	.63**		.20
Intrinsic Goals	.49**	.08	.75**		.14
Control of Learning	.21**	.04	.23**		.05
Test-Anxiety	.33**	.13	.25*		.10
Parents' Support	.62**	.11	1.02**		.19

Note. *p < .05. **p < .01.

In both the male and the female group, students' self-efficacy beliefs, value of science, intrinsic goals, and control of learning belief were associated with one another to a large degree. In addition, for both groups, the perception of parental support was moderately associated with self-efficacy, value of science, extrinsic goals, and intrinsic goals. However, the two groups differed in the relationships of test-anxiety with other factors. The positive correlation between extrinsic goals and test-anxiety was large (r = .61) for the male group and moderate (r = .36) for the female group. In the male group, test-anxiety was also correlated with perception of parental support to a medium degree but not with other factors. Thus, for male students, regardless of their level of self-efficacy, value of science, intrinsic goals, and control of learning beliefs, a high level of performance or ego-involvement goals or a high level of perception of parental support was found to evoke negative affect in testing. Whereas, in the female group, test-anxiety was negatively associated with self-efficacy and control of learning belief to a large degree, and it was also negatively associated with value of science and intrinsic goals to a moderate degree. Its correlation with perception of parental support was negligible. In addition, both groups differed in the relationship between the value of science and the extrinsic goals. The relationship was significant in the male group (r = .33), but it was not in the female group (r = .09).

Table 14

Factor Correlations Within the Male Group and the Female Group (Within Group Completely Standardized Solution)

	Male						Female					
	SE	TV	EG	IG	CL	TA	SE	TV	EG	IG	CL	TA
TV	.75						.79					
EG	.22	.33					.26	.09				
IG	.69	.92	.25				.71	.87	.07			
CL	.78	.75	.26	.84			.62	.74	.01	.72		
TA	-.17	.10	.61	.10	.12		-.53	-.33	.36	-.30	-.53	
PS	.41	.51	.40	.50	.35	.29	.46	.41	.41	.34	.13	.04

Note. SE: self-efficacy, TV: task-value, EG: extrinsic goals, IG: intrinsic goals, CL: control of learning belief, TA: test-anxiety, PS: parental support.

Gender Differences Within the Science Group

Do the differences in science motivational factors between male and female advanced students also exist among academically advanced students who aspire toward science? To address this question, motivational constructs were compared between female (n = 50) and male students (n = 169) in the science group. In SEM, two approaches to modeling latent means comparisons across different groups have been advocated: the multiple indicators and multiple causes (MIMIC) modeling (or group code analysis) and the structured means modeling (Hancock, 1997; Kline, 2005; Thompson & Green, 2006). A MIMIC model incorporates grouping variables as covariates into the measurement model and examines mean differences in latent factors across the groups, rendering a greater model degree of freedom than the alternative method of measurement model with mean structures would (Thompson & Green, 2006). Doing so, it pools covariance matrices of compared groups based on the implicit assumption that the population covariance matrices are homogeneous as is assumed in MANOVA (Hancock, 2001; Thompson & Green, 2006). In social scientific research, however, the assumption of equal covariance matrices can be hardly met. Researchers have used MIMIC approaches given the assumption that the groups are not significantly different or are at least partially invariant regarding factor loadings, intercepts, and error variances (e.g., Kline, 2005). Because of the small number of female students included in the science group, a MIMIC model was specified to investigate gender differences among the science group. The Simplis syntax for this MIMIC modeling is included in Appendix K.

Test of measurement error invariance. I tested whether the partial scalar invariance model for the male and female groups holds additional measurement error invariance constraints, to base a further MIMIC analysis that aimed to estimate mean differences in the motivational factors between male and female science students. The Simplis syntax used is included in Appendix J. That test yielded the following goodness of fit indexes: χ^2 (df = 1163) = 2386.90 (p=0.0); RMSEA = .074; 90% CI for RMSEA = (.070; .079); NNFI = .92; CFI = .93; SRMR = .14. A subsequent chi-square difference test indicated that the measurement error invariance model was not significantly worse than the partial scalar invariance model in terms of model fit: $\Delta\chi^2 / \Delta df$ = (2386.90-2340.23)/(1163-1128) = 46.67/35 ($p > .05$). In conclusion, the measurement model was found to be reasonably invariant across the male and female groups in terms of the factor loadings (with the exception of tv1 and tv4), the intercepts (with the exception of se7, ig3, and ps4), and the measurement errors.

A MIMIC model for factor means in the science group with gender as the cause indicator. In the MIMIC model, the measurement errors of se2 and se4, tv2 and tv6, and cl2 and cl4 were set to covary, in consistence with the previously obtained partial measurement invariance model; and the disturbances of all latent factors were set to covary. The gender variable, on which each motivational factor was to be regressed, was specified as a dichotomous variable so that females were assigned one and males were assigned zero. Thus, the path coefficients from the gender variable to each factor denoted the differences in the factor means of female science students from the factor means of male science students. This MIMIC model is presented in Figure 2. The goodness of fit indexes indicated that overall, the model fit the data fairly well: χ^2 (df = 564) = 1170.51 (p=0.0); RMSEA = .071; 90% confidence interval for RMSEA = (.065; .076); NNFI = .91; CFI = .92; SRMR = .10. The structural equations in which latent factors were regressed on the gender variable and computed standardized factor mean differences are summarized in Table 15.

The structural equations indicated that advanced female students who aspire toward science were significantly different from their male counterparts in the level of intrinsic goals but not in the other factors. Females' level of intrinsic goals was lower than their male counterparts' by as much as .41 standard deviations. Given the higher power of this MIMIC approach to detect mean differences than the analysis of variance (ANOVA) or MANOVA approach, the mean differences is considered small to moderate. Gender accounted for about 3% of the variance in the intrinsic goals (R^2 = 3.0). Female students reported somewhat lower self-efficacy (standardized mean difference = -.22) and higher extrinsic goals (standardized mean difference = .20), but neither of them reached statistical significance.

Table 15

Factor Mean Differences (Male Science Group and Female Science Group)

Equations	SE	R^2	Standardized Mean Difference
se = -.18 × gender	.14	.0086	-.22
tv = -.074 × gender	.10	.0031	-.13
eg = .09 × gender	.09	.0073	.20
ig = -.25* × gender	.12	.030	-.41
cl = -.073 × gender	.084	.0047	-.16
ta = -.065 × gender	.11	.0026	-.12
ps = .071 × gender	.12	.0022	.11

Note. Gender: males (0), females (1). *p < .05.

Overall, female students were not different from their male counterparts statistically in all the motivational factors except for the intrinsic goals. The results partly support Quihuis's (2002) findings that high achieving female students who aspire toward a hard science degree are not different in ability beliefs, value of science, and test-anxiety from their male counterparts. However, the lower level of intrinsic goals found in the current study is not consistent with Quihuis's finding of no gender differences in mastery goals among her sample.

Female students' lower level of intrinsic goals summons our attention. Given the well documented positive effects of intrinsic goals on achievement and motivation, parents and teachers should conceive of ways to promote intrinsic goals among female students. The more female students aim to extend what they learn for further conceptual understanding (rather than being satisfied with getting a good grade), the greater their advancement in the field of science and technology will be.

■ The factor variances and covariances, measurement error variances, and factor loadings were not represented in the figure.

■ The standardized factor mean differences were included in the parentheses.

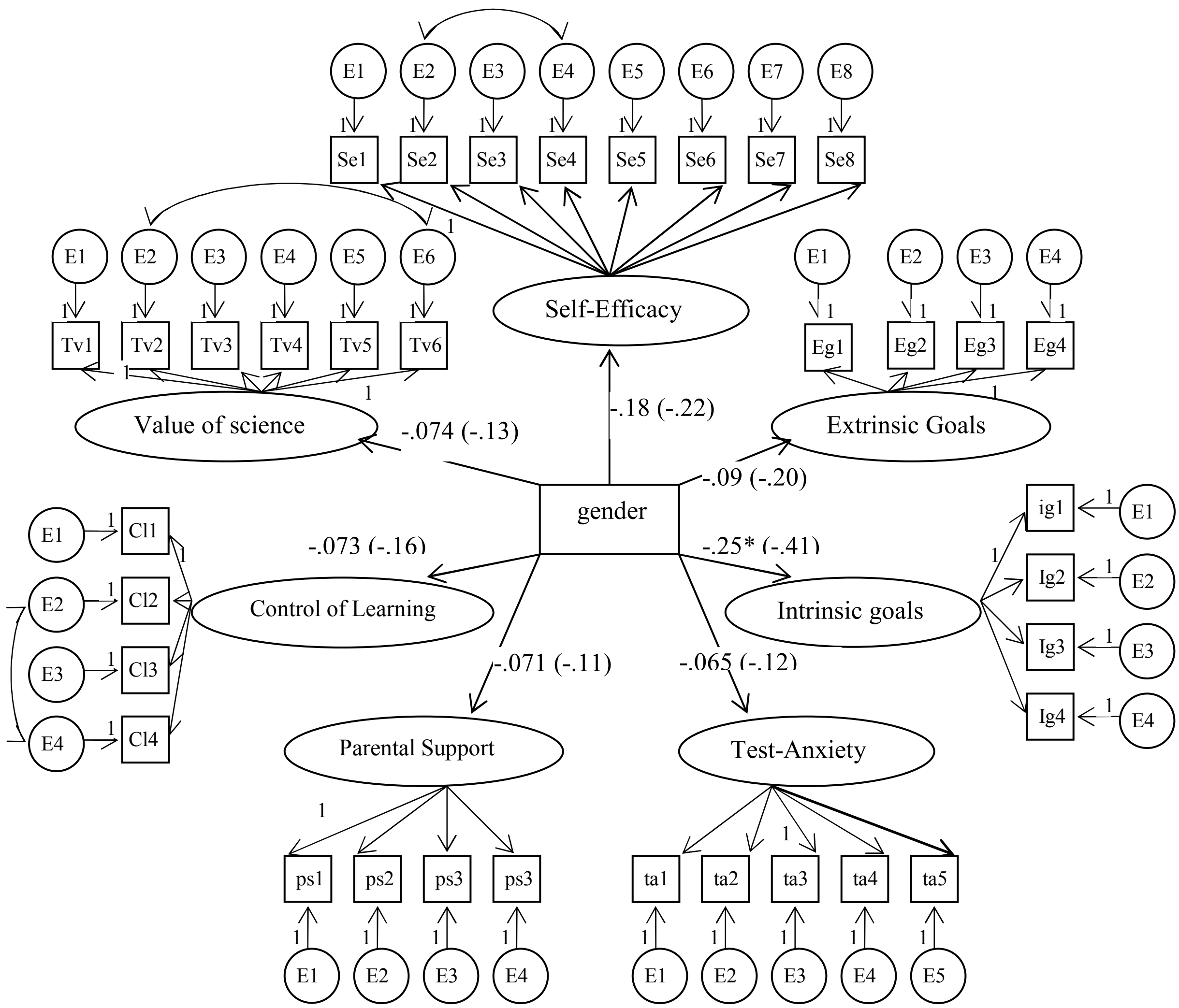

Figure 2. A MIMIC model for gender differences in factor means within the science group

Comparisons Between the Female Science and the Female Non-Science Groups

There has been research endeavor (e.g., Farmer et al., 1999; Mau et al., 1995) to identify the factors that affect female students' aspirations for science by comparing female students who aspire towards science or technology occupations and those who aspire towards the occupations traditionally females engaged in. In line with the research, I compared female students who aspire toward a science degree (n = 50) with those who do not (n = 89). To find factor mean differences between the groups, a MIMIC model was specified in the same way as the MIMIC model discussed in the preceding section. The Simplis Syntax used is included in Appendix L. Yielded goodness of fit indexes were as follows: χ^2 (df = 564) = 1058.54 (p=0.0); RMSEA = .076; 90% confidence interval for RMSEA = (.068; .084); NNFI = .93; CFI = .94; SRMR = .13. Even though no indexes indicated a good model fit except for the value of RMSEA, the fit was not very bad. Obtained structural equations in which latent factors were regressed on the group membership variable are summarized along with computed standardized mean differences in Table 16.

As expected, female science students were found to have a more favorable motivational pattern overall, than female non-science students. On self-efficacy, value of science, extrinsic goals, intrinsic goals, and perception of parental support, science females' means were higher by more than a half standard deviation than non-science females' means. In particular, science females reported much larger perception of parental support (standardized mean difference = 1.51), and the group membership accounted for 54% of the variance in the factor. These findings support the qualitative studies on women in science careers (e.g., Zeldin & Pajares, 2000) which have found that beliefs in ability, value of science, and parental encouragement were critical for the women's persistence in the male-dominating areas.

The groups' mean differences in control of learning beliefs (beliefs in the importance of strategies and efforts for understanding) and test-anxiety did not reach statistical significance, although non-science females' higher test-anxiety (standardized mean difference =.40) seemed substantive. This substantive difference in test-anxiety has not been found in the other comparisons between males and females (standardized mean difference = .04), between science and non-science students (standardized mean difference = .04), and between male science and female science students (standardized mean difference = -.12).

Taken together, the results of this comparison of motivational factors among academically advanced female students indicated that the perception of parental support makes the largest difference in female advanced students' aspirations for science. The effects of other motivational factors such as self-efficacy, value, intrinsic goals, and extrinsic goals were moderate. Thus, the inclusion of parental support factor is warranted for the explanation of females' motivated behaviors in science.

Table 16

Factor Mean Differences (Female Science Group and Female Non-Science Group)

Equations	SE	R^2	Standardized Mean Difference
se = -.56** × group	.15	.106	-.68
tv = -.60** × group	.16	.118	-.71
eg = -.47* × group	.20	.073	-.56
ig = -.47** × group	.17	.076	-.57
cl = -.056 × group	.09	.003	-.12
ta = .15 × group	.10	.037	.40
ps = -1.40** × group	.19	.535	-1.51

Note. Group: Female Science Students (0), Female Non-Science Students (1). *p < .05. **p < .01.

Structural Regression Model of the Aspirations for Science

Based on the findings reported in the previous sections, I determined the predictors to be included in a structural regression model to explain advanced high school students' aspirations for science in general and gender differences in particular; these were self-efficacy, value of science, and perception of parental support. Even though extrinsic goals, control of learning belief, and intrinsic goals also differentiated the science students from the non-science students, I did not include them in the model for two reasons other than model parsimony. First, no significant gender differences were found in the extrinsic goals or control of learning belief. Second, the intrinsic goals factor overlaps with the value of science to a great degree, as evidenced by their very high correlation, around .90 in each group.

The model was specified as follows:

1) Guided by the expectancy-value theory, I set self-efficacy and value of science to affect aspirations for science and parental support to affect self-efficacy and task-value.

2) I set parental support to directly affect the aspirations for science, as parental support was found most influential on the aspirations for science in the current sample.

3) I set self-efficacy to affect parental support, based on the intuition that parents may support their children's science learning more actively when their children are confident and do well in science; and based on social cognitive theory (Bandura, 1986), according to which students' beliefs affect their environment such as parents' expectations. However, this specification resulted in a reciprocal relationship between the two exogenous factors, parental support and self-efficacy. As neither of the effects was a concern in this study, I let them covary by default of the Lisrel, rather than estimating each effect on the other.

4) Finally, I set self-efficacy to affect value of science rather than setting them to interact, guided by the findings from interviews, which will be presented in the later section on interview data analysis, and by Eccles, Wigfield, and Schiefele (1998) and Greene et al. (1999).

The structural regression model is presented in Figure 3. For brevity of presentation, the measurement part was deleted.

In the model, the criterion variable, aspirations for science, was measured only with one indicator: "I will major in science, math, or engineering in college." For model specification, I needed to give a value to the item's reliability so that its error variance could be determined. The reliability was set to a relatively high value .90 because the item was considered to be straightforward in its meaning. In addition, I set the item's loading on the aspirations for science factor to be one, so that the factor could be identified. The other measurement part of the full model was consistent with the factor analyzed measurement models presented in previous sections. In other words, two error covariances, one between se2 and se4 and the other one between tv2 and tv6, were set to be freely estimated. The Simplis syntax used is included in Appendix M.

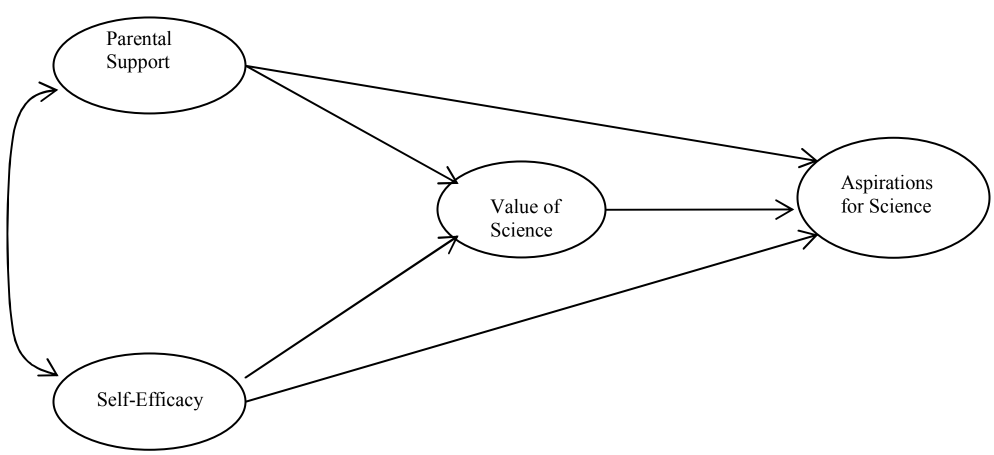

Figure 3. *Structural regression model of the aspirations for science*

This model was supported by favorable goodness of fit indexes: χ^2 (df = 145) = 344.42 (p=0.0); RMSEA = .062; 90% confidence interval for RMSEA = (.053; .070); NNFI = .98; CFI = .98; SRMR = .061. All the indexes except for the value of χ^2 indicated that the model fit the data very well. The obtained parameters are summarized in Table 17.

The predictors— perceived parental support, value of science, and self-efficacy— explained a large amount of the variance in the aspirations for science (R^2 = .66). According to the provided total standardized parameters, perceived parental support had the largest positive effects on the aspiration variable (ɣ = .77) followed by value of science (ɣ = .24). However, the total effects of self-efficacy on the aspiration variable did not reach statistical significance or substantive (ɣ = .07). Value of science was, in turn, explained by self-efficacy and perceived parental support in a large degree (R^2 = .61). In particular, self-efficacy was very influential on value of science (ɣ = .67). A diagram of the model is presented in Figure 4. The measurement parts of the latent factors are not presented in the diagram for the brevity of presentation.

Table 17

Parameter Estimates for Structural Regression Model

	Unstandardized Path Coefficients	SE	Standardized Path Coefficients	Total Effects	
				Unstandardized	Standardized
se → tv	.57**	.060	.67	.57**	.67
ps → tv	.17**	.046	.20	.17**	.20
se → asp	-.23	.17	-.10	.16	.07
tv → asp	.67**	.22	.24	.67**	.24
ps → asp	1.70**	.17	.72	1.81**	.77

Note. For standardized values, statistical significant was not provided. **p < .01.

According to this model, perceived parental support is more critical than beliefs in the ability to do well in science courses for advanced high school students' aspirations for science or intention to major a science in college. Students' interest, perceived usefulness, and perceived importance of science courses also contributed their aspirations for a college science degree. These findings contradict the expectancy-value theory which posits value and expectancy as the most essential predictors of achievement motivation, but posits that parents (social environment) influence motivation with the mediation of value and expectancy. This discrepancy may be because the sample used in this study, academically advanced Korean students, may be more subordinate to their parents' influence for their academic decisions than their Western counterparts as indicated by Kim and Park (2006). Additionally, the insignificant contribution of self-efficacy to aspirations may reflect the Korean students' expectation that college science programs should require a lot higher standards than their high school science courses do. Further studies to apply this model to Western advanced student samples will advance this discussion.

- **$p < .01$.
- Standardized path values are presented in the parentheses.

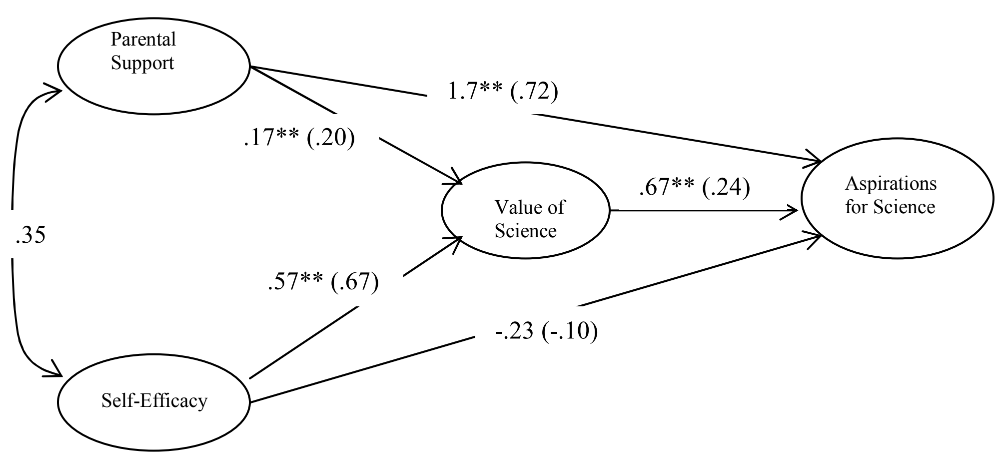

Figure 4: The Aspirations for science of academically advanced high school students

Gender differences. To compare gender differences in the parameters of the structural regression model, I conducted multiple-sample SEM. I added the structural part (which was diagrammed in Figure 4) to the previously established measurement invariance model for the male and female groups so that structural parameters could be estimated for each group. The Simplis syntax used is included in Appendix M. The analysis yielded the following fit indexes: χ^2 (df = 340) = 638.61 (p=0.0); RMSEA = .069; 90% confidence interval for RMSEA = (.060; .077); NNFI = .97; CFI = .97; SRMR = .13. The RMSEA and its 90% confidence interval and the incremental indexes NNFI and CFI indicated that the model reasonably fit the groups.

The model explained the aspirations for science better for the female group than for the male group. In the male and the female group, the explained variances in the aspirations for science by the three predictors were 53% (R^2 = .53) and 69% (R^2 = .69), respectively; the explained variances in the value of science by self-efficacy and perceived parental support were 58% (R^2 = .58) and 72% (R^2 = .72), respectively. The detailed ML parameter estimates for each group are presented in Table 18.

According to the common metric standardized parameters, perceived parental support had the largest total effect on the aspiration variable (ɣ = .67 for the male group and ɣ = .86 for the female group) followed by the value of science (ɣ = .28 for the male group and ɣ = .31 for the female group). Female students were more influenced by their perception of parental support for their aspirations for a science degree than male counterparts were. However, the total effect of self-efficacy on the aspiration variable was not statistically significant or substantive for either group.

The groups differed in the effect of perceived parental support on the value of science. In the male group, the effect was significant (ɣ = .22), suggesting that advanced male students' value of science is affected by their perceived parental support to some degree. In the female group, however, the effect did not reach statistical significance (ɣ = .10), suggesting that advanced female students develop their value of science without much influence from their parents. Value of science was more strongly influenced by perceived efficacy for both groups. In particular, the effect was larger for female students (ɣ = .90) than for male students (ɣ = .58). Meanwhile, the analysis yielded the same amount of correlation between perceived parental support and the self-efficacy variable for both groups (r = .45). A diagram of the model is presented in Figure 4. The measurement part of each latent factor is not presented for brevity of presentation.

Table 18

Parameter Estimates for Structural Regression Model (Male Group and Female Group)

	Unstandardized Path Coefficients	SE	Standardized Path Coefficients	Total Effects: Unstandardized	Total Effects: Standardized
Male Group					
se → tv	.49**	.063	.58	.49**	.58
ps → tv	.18**	.055	.22	.18**	.22
se → asp	-.28	.19	-.13	.06	.03
ps → asp	1.29**	.17	.61	1.41**	.67
tv → asp	.70*	.27	.28	.70*	.28
Female Group					
se → tv	.76**	.09	.90	.76**	.90
ps → tv	.080	.07	.10	.080	.10
se → asp	-.44	.36	-.20	.16	.07
ps → asp	1.77**	.22	.84	1.83**	.86
tv → asp	.78*	.39	.31	.78**	.31

Note. The standardized coefficients are common metric completely standardized solutions.

*p < .05. **p < .01.

■ The path coefficients represent the common metric standardized parameters.

■ Female group's parameters are presented in the parentheses.

■ *p < .05. **p < .01.

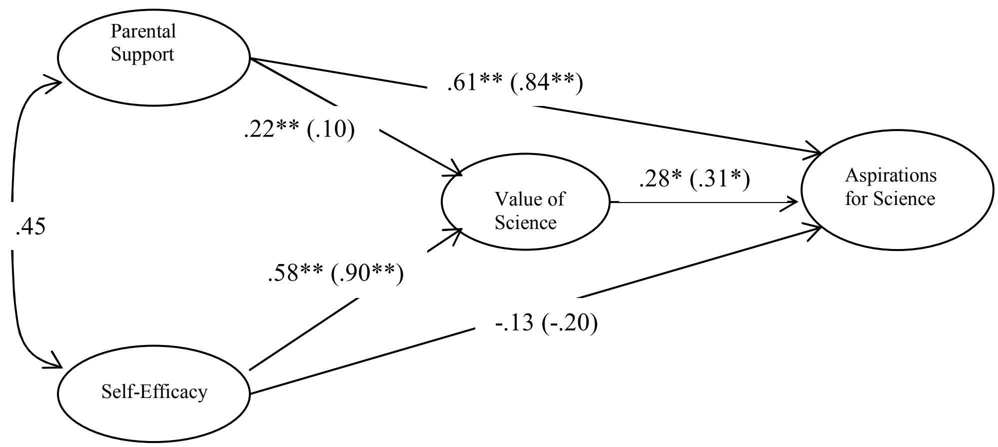

Figure 5: Structural regression model of the aspirations for science (gender differences)

CHAPTER V

ANALYSIS OF THE OPEN-ENDED QUESTIONS

The three open-ended questions included in the questionnaire conveyed the information on participants' extra-curricular science activities, self-conceptions of their own strength for science, and rationales for choosing or opting out of science. I compiled all the participants' responses into an Excel file, with an emphasis on preserving their own accounts as much as possible. Thus, the students whose Likert-type item responses were excluded from the statistical analyses because of some missing variables included or because of their being statistical outliers were included in this analysis. The responses for each item were categorized, and the frequencies of each category included in each student's response were tallied. When students indicated more than one category in their response, each category was tallied so that for some items, the number of responses exceeded the number of respondents. Then, the frequencies of each category were compared across interested groups.

Extra-Curricular Science Activities

Science students versus non-science students. Overall, in both groups, engagement in extra-curricular science activities was more related to individual learning of additional science content rather than cooperative activities or research activities. In South Korea, private academic programs with various purposes which students attend after school or on the weekends are prevalent in most cities. A large number of students reported their attendance at private academic programs in which they were learning additional science content to prepare for school examinations or the national science Olympiads. The response was more prevalent among the science students (69.8%) than among the non-science students (29.3%). Considering the school science clubs which were also focused on academic enhancement, the proportion of science students who were taking additional courses beyond regular school courses reached 84.7%. Unexpectedly, the proportion of students who participated in a regional gifted program in elementary or in middle school was slightly larger for the non-science group (9.6%) than the science group (8.5%). The proportion of the students who reported their engagement in individual research was also less than 10% in each group. Meanwhile, the proportion of the students who reported their participation in science competitions other than the science Olympiads was larger in the non-science group (4.5%) than in the science group (0.4%). About 4.7% of the science students and 21.7% of the non-science students reported not being involved in any kind of extra-curricular science activity. Figure 6 compares the proportions engaged in each activity. The tables from which the following figures were generated are included in Appendix N.

■ science group (N = 235), non-science group (N = 157)

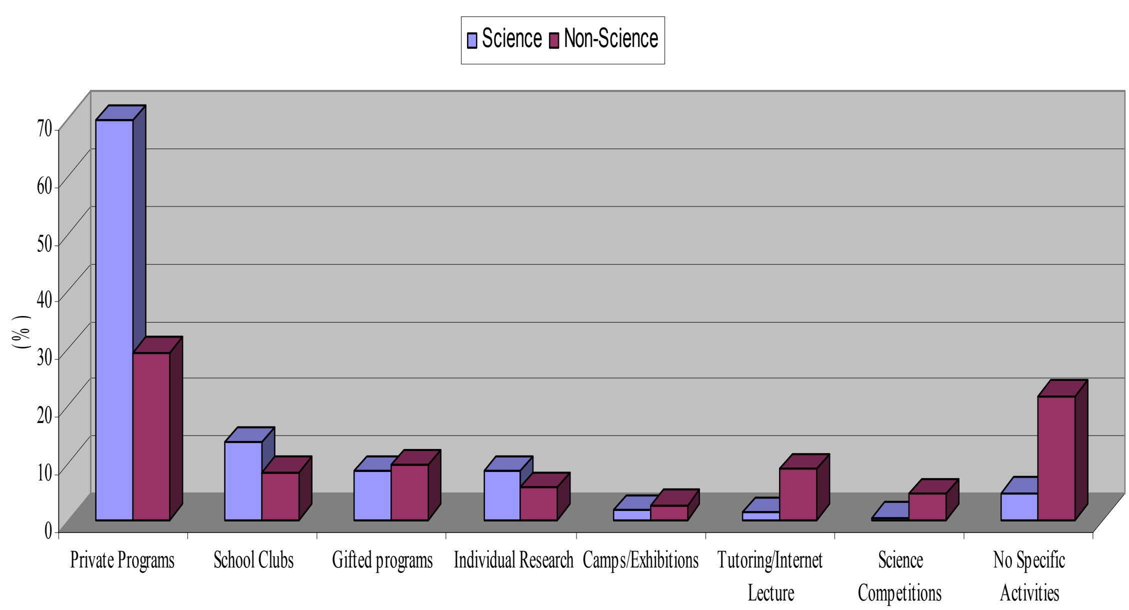

Figure 6. Extra-curricular science activities (science group versus non-science group)

Male science students versus female science students. Among the science students, male and female students did not differ much in the activities they have been engaged in. These students' extra-curricular science activities were mostly limited to attendance at academic enhancement programs either private or given by school teachers. In both groups, the proportion of the students who had attended a regional gifted program was around 7%. The proportion of the students who reported their participation in individual research was slightly larger in the female science group (10.9%) than in the male science group (7.8%). It may be that the students did not have much time to engage in hobby-like activities or to experiment with their creative ideas on their own way because of their heavy course loads and their school environment, which required competition with able peers to earn good GPAs. Figure 7 presents the proportions of students who engaged in each activity for both male and female science groups.

■ male science group (N = 180), female science group (N = 55)

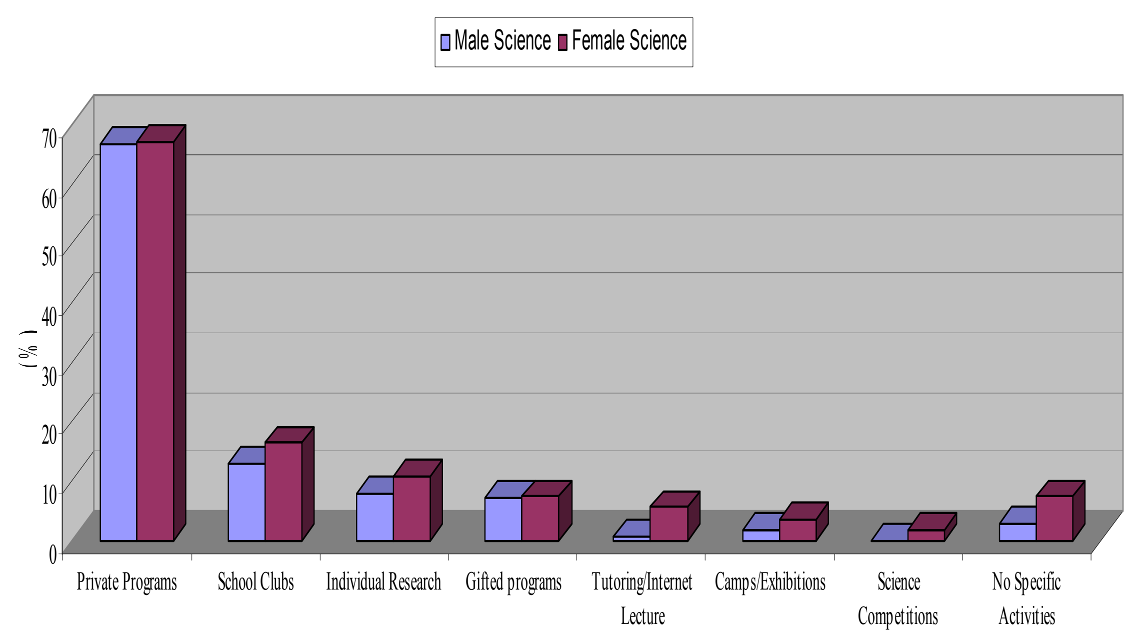

Figure 7. Extra-curricular science activities (male science group versus female science group)

Female science students versus female non-science students. The groups differed markedly in the proportion of the students who participated in private academic programs or who received private tutoring: 72.8% of female science students versus 28.1% of female non-science students. Unexpectedly, however, the rate of students participating in a regional science gifted program or a science competition (not including the science Olympiads) was slightly higher in the non-science female group (8.3% and 6.3%, respectively) than in the science female group (7.3% and 1.8%, respectively). Meanwhile, more non-science females reported that they had not been involved in any extra-curricular science activity (26.0%) than science females (7.3%). Figure 8 presents the proportions of students who engaged in each activity for both the female science group and the female non-science group.

■ female science group (N = 55), female non-science group (N = 96)

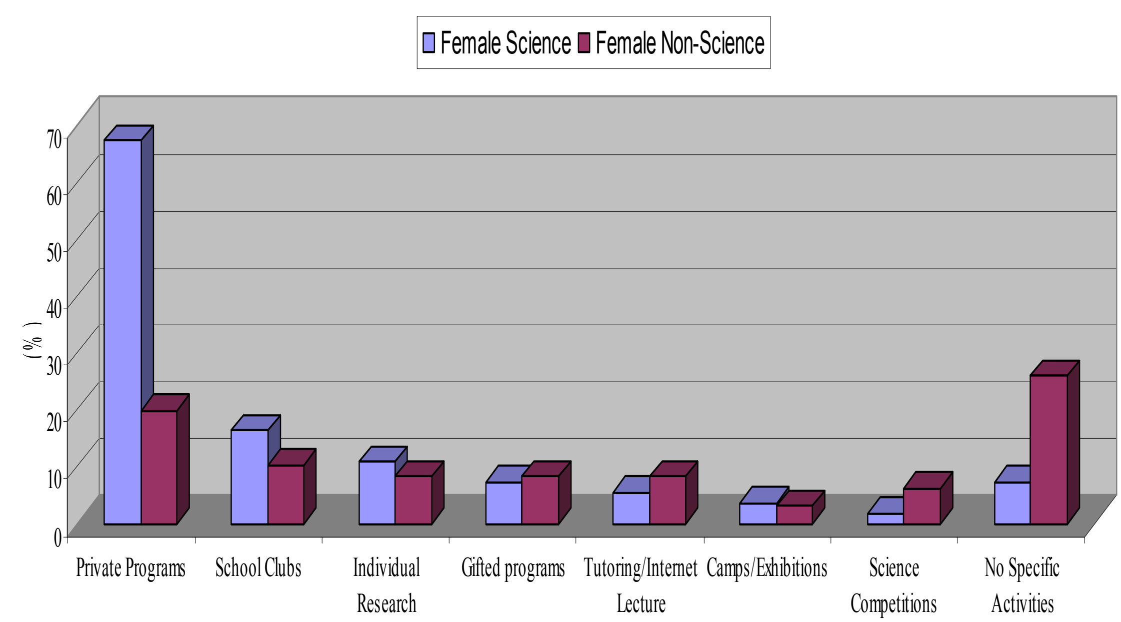

Figure 8. Extra-curricular science activities (female science group versus female non-science group)

Self-Concept of Students' Own Strengths for Science

With respect to the concept of their own strengths for science learning, the participants' responses were various, resulting in several broad and somewhat overlapping categories: persistent personality or attitude (e.g., scrupulousness, persistence, concentrating, exerting continuous efforts, sincerity, careful observation) ; intrinsic interest (e.g., desire for understanding, inquiring attitude, curiosity, interest); ability (e.g., analytic power, comprehensive power, aptitude, good memory, self-efficacy); seeking challenge (e.g., competitiveness); passion; creativity (e.g., imagination); and others (e.g., liking experiments, recording skill, organizing skill, confidence in math, optimistic thinking, relaxed attitude, social ability, self-regulated learning, and advanced learning).

While the persistence attribute was the most frequent response indicated as their own strengths for the science students (36.4% of the students), intrinsic interest or inquiring attitude was the most frequently indicated strength among the non-science students (45.6%). The proportion of the students who indicated ability or challenge-seeking was larger in the science group (14.0% and 4.2%, respectively), but such responses were rare among the non-science group. Thus, it seems that more science students recognize the importance of persistent efforts for science learning and have confidence in their ability than their non-science counterparts.

Differences between the male and the female group in the self-concept of own strengths for science were in line with the differences between the science and the non-science group. Persistent personality was the most prevalently indicated strength among male students (33.9%), whereas intrinsic interest or inquiring attitude was the most prevalently indicated strength among female students (48.7%). The proportions of intrinsic interest or inquiring attitude among the male group and of persistence among the female group were similar (29.8% and 33.3%, respectively). The proportions of the students who indicated ability, challenge seeking, or passion as their strength were larger in the male group.

Within the science group, the indication of the persistence or intrinsic interest attributes was more frequent among the female science students (38.2% and 40.0%, respectively among the female group; 35.6% and 29.4%, respectively among the male group). However, the responses related to ability, challenge-seeking, or passion were more prevalent among the male science group (16.1%, 4.4%, and 3.3%, respectively among the male science group; 7.3%, 3.6%, and 1.8%, respectively among the female science group).

When comparing the female science and the female non-science students, some differences were manifested in the strengths other than the persistence attribute. The responses related to intrinsic interest were provided more frequently by female non-science students (54.2% versus 40.0%), but those related to ability or seeking challenges were more frequently provided by female science students. However, it seems not desirable to generalize the results because of the small number of the responses in each group. Figure 9-14 illustrates the proportions of responses from each group with regard to the strengths. The table from which the graphs were generated is presented in Appendix O.

■ The number of students in each group: science group (n=236), non-science group (n=158), male group (n=242), female group (n=152), male science group (n=180), female science group (n=55), female non-science group (n=96).

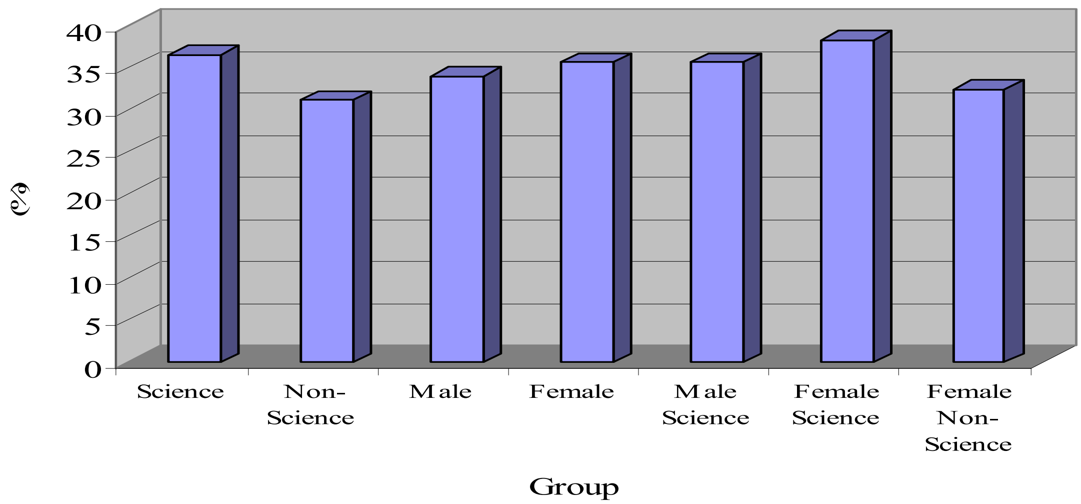

Figure 9. Proportions of students indicating persistence in science as their strength

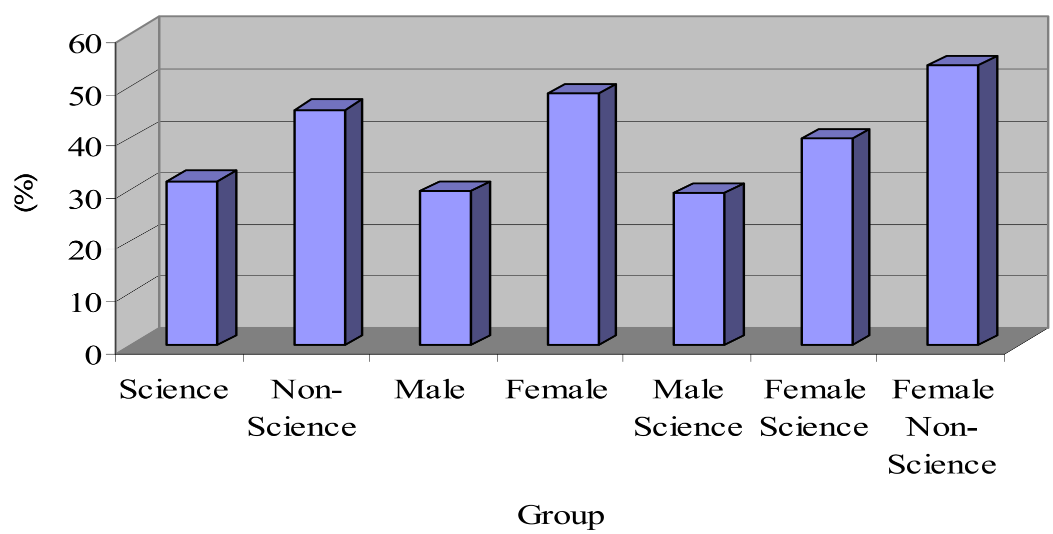

Figure 10. Proportions of students indicating intrinsic interest in science as their strength

■ The number of students in each group: science group (n=236), non-science group (n=158), male group (n=242), female group (n=152), male science group (n=180), female science group (n=55), female non-science group (n=96).

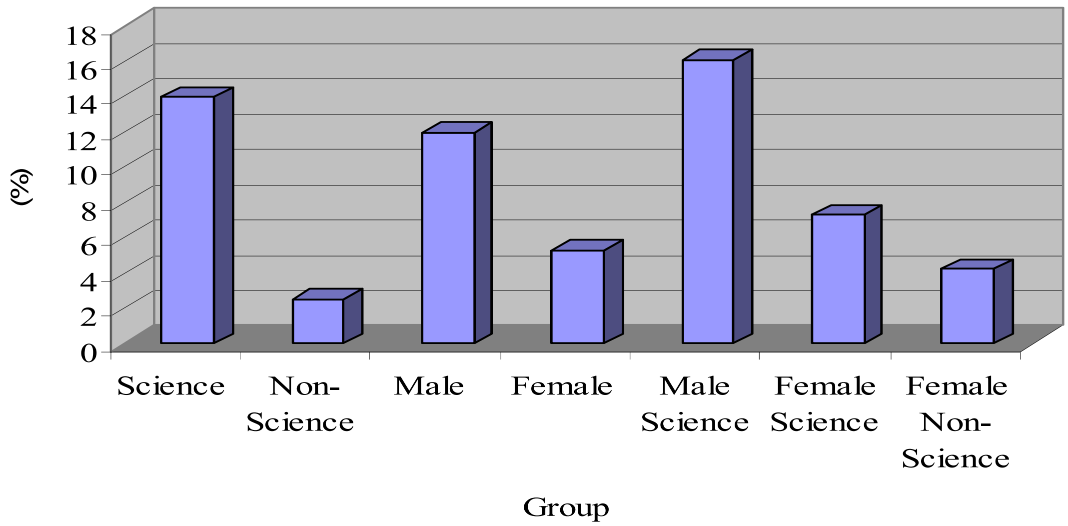

Figure 11. Proportions of students indicating ability as their strength

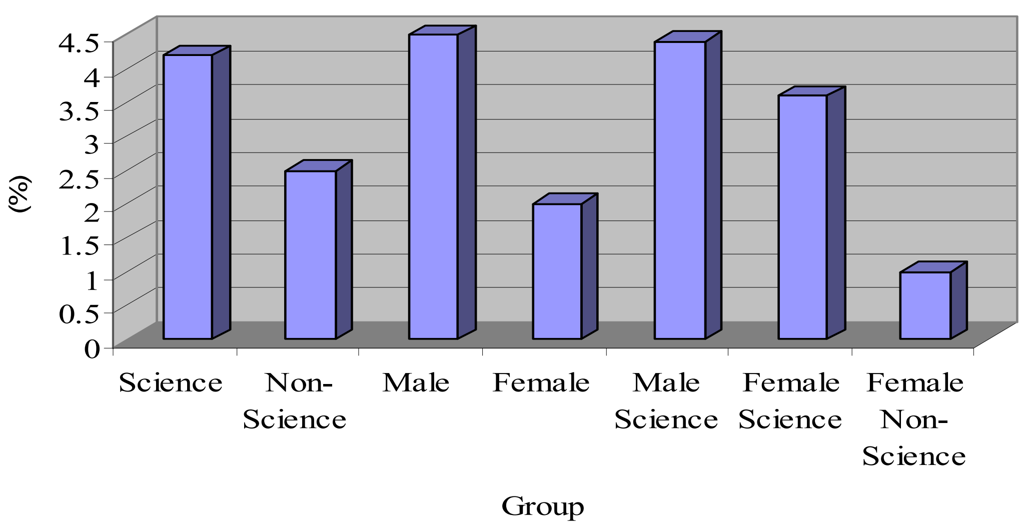

Figure 12. Proportions of students indicating challenge-seeking in science as their strength

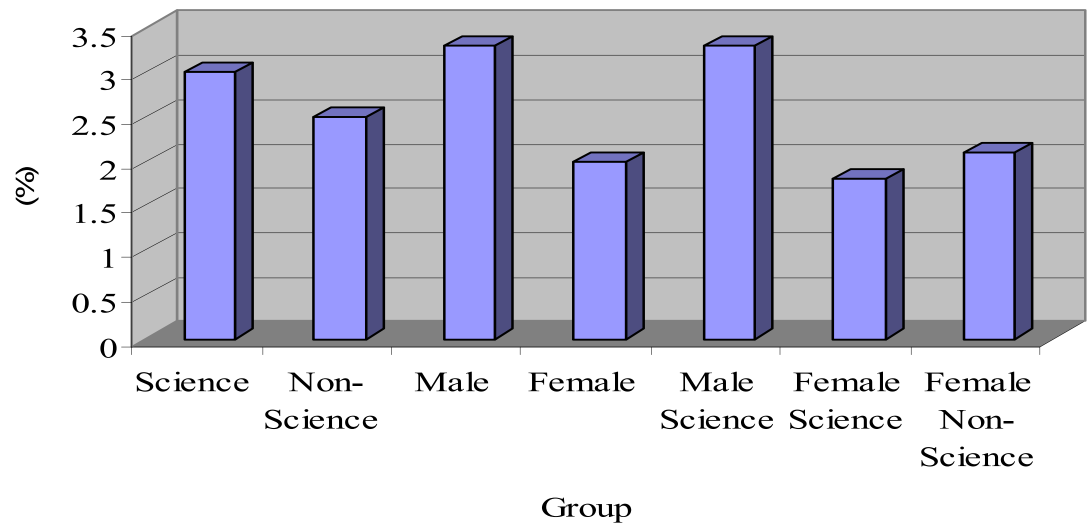

Figure 13. Proportions of students indicating passion for science as their strength

■ other responses (e.g., liking experiments, recording skill, organizing skill, confidence in math, optimistic thinking, relaxed attitude, social ability, self-regulated learning, and advanced learning).

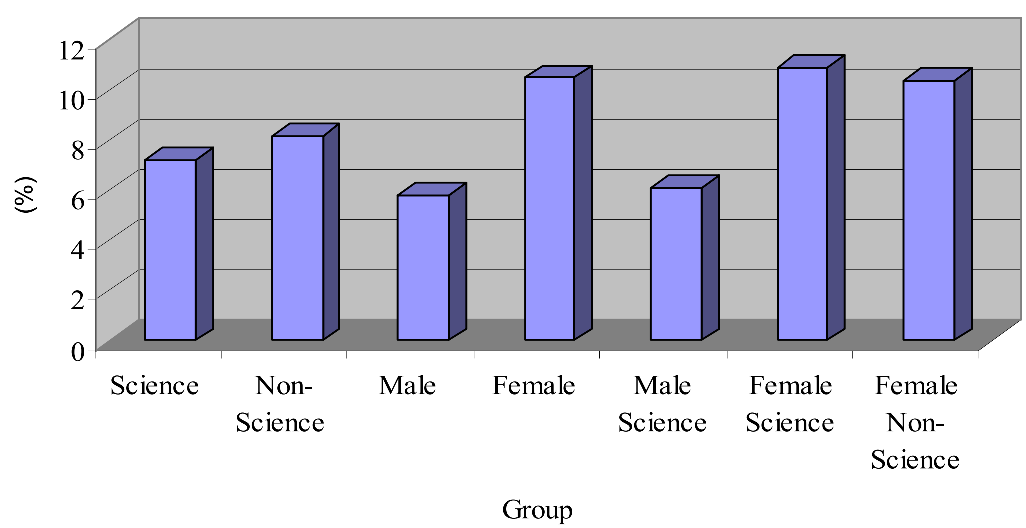

Figure 14. Proportions of students indicating one of the other responses as their strength

Rationale for Choosing or Opting out of Science

Science students' rationale for choosing to major in a science in college and non-science students' rationale for choosing to opt out of science varied. Their responses were classified into several broad categories, and the frequencies of each category were tallied. The results are summarized in Table 19.

Above all, intrinsic interest was the most prevalent reason for science students' choosing a science for their college major (60.0% of science males and 47.3% of science females). The next prevalent reasons were related to perceived efficacy or ability (13.9% of science males and 18.2% of science females) and to their good performance or accumulated substantive knowledge (13.3% of science males and 20.0% of science females). The proportion of the students who provided an altruistic reason (e.g., for their country's development, for the improvement of human wellbeing) was 6.1% in science male students and 5.5% in science female students. Interestingly, no one student provided a rationale related to their parents' influence. It may be that the science students reflected only on their own attributes when asked to provide their reasons for choosing science.

Regarding non-science students' reasons for opting out of science, interest-related reasons were the most prevalent (33.8%): more interest in subjects (or jobs) other than science or no interest in science. Following the interest-related reasons, efficacy-related reasons were provided by 24.2% of non-science students: difficulty with and relatively poor performance in science and/or math or better performance in the other subjects than science. The proportion of the students who indicated it was not a good fit for their personality (e.g., lack of persistence) or that they lacked the aptitude was also substantive (20.4%). In addition, 9.6% of the students indicated unpromising job conditions (e.g., hard to earn wealth or prestige, limited job choice, hard to get a job, expected stress) as their reason for opting out of science.

Table 19

Students' Rationale for Choosing or Opting out of Science

Reasons for Choosing Science	Science Male Students (N=180)	Science Female Students (N=55)	Reasons for Opting Out of Science	Non-Science Students (N=157)
Having intrinsic interest	108 (60.0)	26 (47.3)	More interest in other subjects/ Lack of interest/ More interest in other jobs	53 (33.8)
Having aptitude or ability in it/ Self-efficacy	25(13.9)	10 (18.2)	Too complicated and difficult/ not doing well in science and math/doing better in the humanities or social sciences	38 (24.2)
Having learned a lot of science and math/ Success in the content areas	24 (13.3)	11 (20.0)	Does not fit personality/ lack of aptitude/having aptitude in the humanities or social sciences	32 (20.4)
For my country's science development/for wellbeing of mankind	11(6.1)	3 (5.5)	Hard to earn wealth or prestige/ Limited job choice/ hard to get a job/ Expected stress from a science job	15 (9.6)
To find new facts/to find nature's regularity/ To develop science /To apply science in real life	11 (6.1)	3 (5.5)	Irrelevant to future dream	7 (4.5)
Prospective/ To earn money using scientific knowledge/ to get a good job/ To attain specialty	10 (5.6)	4 (7.3)	Cost of tuition	1 (0.6)
To realize my dream	8 (4.4)	2 (3.6)	Hard to get into college	1 (0.6)
My personality fits it well	4 (2.2)	1 (1.8)	Parents do not want me to pursue this	1 (0.6)
To compete with many others	2 (1.1)	0	Want to be a doctor	1 (0.6)
Easier college admission	1 (0.6)	1 (1.8)		
Obligation as a gifted student in science	1 (0.6)	0	Not determined major, yet	1 (0.6)
To follow my mother's path	0	1 (1.8)		
Liking clear logic	0	1 (1.8)		
Total Responses	205	63	Total Responses	150

Note. The percentage of each category presented in the parentheses was calculated based on each group's sample size N.

CHAPTER VI

ANAYSIS OF INTERVIEWS

Semi-structured interviews were conducted to obtain more elaborated responses from academically advanced high school students regarding their science learning and their parents' support for it. Among the six interviewed participants, two students (Min and Jun) participated in the interview as they agreed to and I could contact them (They designated their phone number on the consent form). The other four students (Yun, Tak, Sun, and Dale) were selected by their science teacher among the students who agreed to the interview and who were enthusiastic in science. Each interview took 35 to 40 minutes and took place during lunch time or after school in one of school facilities such as the parents' meeting room, the English classroom, or the science lab.

The academic quality of the participants is well explained by their attendance at the selected high schools. The schools were established according to the South Korean government's policy to advance the education of gifted students in the sciences or the development of national leaders equipped with language skills adequate to work globally. The school had dormitory facilities to accommodate all enrolled students. Students stayed in the dorms and returned home every weekend during the semester. In selecting students, the schools applied very high selection criteria implying that their students were the top students in middle school or winners of a gold prize in the national science Olympiads. Among the high schools, two schools (East High School and West High School) provide advanced curriculum for science and math and the Individual Research program to all enrolled students. At their tenth grade, the schools' students take physics, chemistry, biology, and earth science in addition to two math courses which cover eighteen class hours a week in total. By contrast, the other high school provides advanced programs for English and social sciences, but it provides only elective lab courses beyond the national common curriculum for science to eleventh graders.

Participants' demographic information is summarized in Table 20. Pseudonyms were used for participants and their schools. One student was the second child in her family; three were the eldest children in their families; and two were the only child in their families. Among the four students who will be labeled as science students in this chapter, three hoped to major in science or technology, and the other one hoped to double major in chemistry and business in college. However, the other two, who will be labeled as non-science students in this chapter, hoped to major in business in college.

While reading the first transcription of Min's interview repeatedly, I came up with several categories that classified her responses (Gillham, 2000). This process was followed with the rest of the transcriptions, and a new category was added when a substantive statement which did not fit previous categories was found. Several statements were assigned to the 'unclassified statements' category (Gillham, 2000). The final list of categories included self-efficacious, interested in science or math, boosting self-concept, autonomous decision making, liking hands on experiments, liking abstract problem solving, personally important science, appreciation of practical value of science, performance goals, learning goals, dedication to science Olympiads, entering prestigious college, supportive parents, recognition of parents' influence on pursuing science, recognition of others' influence, and engagement in various activities. The categories were then rearranged according to the themes emerged from the texts.

Table 20

Participants' Demographic Information

Group	Name	Gender	Sibling	School	Favorite Science Subject	Intended College Major	Future Career
Science	Min	F	One older brother	E. H. S.	Biology	Neuro-science	Neuro-scientist
	Jun	M	Only child	E. H. S.	Earth Science	Astronomy	Astronomer
	Yun	F	One younger sister	W. H. S.	Chemistry	Chemistry and Business	Venture CEO in Science Area
	Dale	M	One younger sister	W. H. S.	Physics	Engineering or Physics	Don't know
Non-Science	Sun	F	Only child	S. H. S.	Physics	Business	CEO in Science or Technology Area
	Gyu	M	One younger brother	S. H. S.	Chemistry	Business	CEO

Why Do I Like Science?

The participants had a specific science subject they liked the most. With respect to the question asking what aspects of the subject they liked, their responses varied. However, the responses suggested two common themes: experiences of immersing themselves into science; enjoyment of learning new content and logically solving abstract problems. They seemed to be emotionally attached to the subject.

Min: At first I thought biology was about memorizing, but as I studied further I found that if you understand things, the memorization comes automatically, and it was cool to see there were reasons behind all the names. So I could understand things better as well.
Jun: You don't see any numbers in the problem, but when you're solving it, you have to think from a physics point of view, that's what astronomy's about. It's a lot of fun. It's like solving a code, so no matter how long it takes, it's still fun.

Yun: Thinking about things I couldn't understand, even for days, and then finally figuring it out, those moments were the most fun. . . . If you're doing well in a subject it really gives you confidence. So it's a subject that sometimes I have to dig deep into, but there is a kind of dependence. It feels like a friend. . . . If I'm doing math and it's not going well, I do chemistry and feel something like comfort. In that respect, it gives me emotional comfort in terms of self-satisfaction and the reassurance that I am capable of doing something.

Dale: I like it best when I solve things like complicated equations of motion and they're generalized.

Sun: With physics, I like the fact that you have to keep thinking. Even when you're just calculating momentum, there are lots of variables and you have to think about all of them and there is a process where you have to take every one of them into account. That kind of thing, where you have to think about each and every factor, I like that very process.

Gyu: Both of my parents majored in chemistry so since I was young I had a vague sense of awe towards it. . . . As I get to know a bit more there is an element of admiration, but more than that there is a joy to finding things out. . . . I think the joy that comes from getting to know one thing at a time had a big effect on my life.

The participants' interest in science was rooted in their positive learning experiences which were related to learning complex and advanced content, succeeding in solving challenging problems after persistent efforts on their own, and accomplishing a collaborative project successfully. They were curious and liked problem solving processes per se, as much as successful outcomes. They were readily spending a significant amount of time engaging in solving abstract problems, and they enjoyed the moment when the problem was solved.

> Sun: I entered a contest where you let an object fall and you have to do certain calculations and build a structure that lasts the longest. I entered that contest as a team with my friends and that was the first competition that I'd entered so we put a lot of effort into it and the result was very good. After doing that once I realized it was a lot of fun, and I'd read many books in that direction and I'd actually put what I knew into practice and the result came out very well, so you could say there was a lot of satisfaction? So I like all four [sciences] but it seems I've been getting more interested in physics.

In particular, two participants who reported their liking of chemistry recollected their experiences doing experiments in gifted programs in elementary school or in middle school. To these students, the experiments left a deep impression in their minds that did not dissipate even after years.

> Yun: [In 4^{th} grade at a gifted science program] there were experiments with elementary school students participating. Making science newspapers and reproducing the mechanism of tornadoes directly with experiment and other simple experiments like extracting liquid from herb-like plants. . . . That made a big impression on me. Because it was the first experiment in elementary school.

Gyu: After elementary school, in middle school, I entered a small gifted program run by the office of education and we did some activities and especially in chemistry the most awesome thing was, as a little kid, [seeing] a metal hook being dipped in some liquid and if you burned it in fire you could see strange flames. After growing up I found out that was a flame reaction but back then it seemed so weird and wonderful I still remember it.

Science students had a clear preference for science over humanities subjects. They appreciated the usefulness of science for modern living and appreciated the variety of content in science; however, they tended to consider social sciences and literature as boring and mundane. For them, the latter subjects seemed to have little relevance to real life or other subject areas. In contrast, non-science students appreciated the need for balanced learning across science and social studies, such as business, and saw the role of science as a means to solve problems (e.g., the energy crisis) as well as the necessity of learning business for the realization of their goal to be a CEO.

Min: I didn't like it when they talked about having to feel a certain way because other emotions weren't in there [in poems, for example]. I don't think I'm cut out for Korean. . . . Science is still helpful today. For example old methods can still be applied to modern technologies. . . . But I don't understand why we have to learn the history of foreign countries. Even when I did study it, I didn't really want to, and had a hard time understanding it and was frustrated, so I gave up.

Jun: English or Korean classes seem identical every day, with just the title of the chapter changing and everything else the same. But in science, even in the same chapter, the page that comes after is different from the one that comes before in terms of content. There is something new every time you turn the page but with [humanities subjects] . . . I can't do it because it's boring

Yun: I started preparing for science high school admissions in seventh grade…. Back then as I studied chemistry I found it a lot of fun, and science was more fun than Korean or social sciences.

Dale: In science if you develop a technology or produce good research results it can be used in real life to upgrade people's lives around the world. But it seems, for example with literature, that there is much less of that. . . In the first place, I don't like that you have to memorize a lot of things in social science. . . With literature, I think writing is a very fun thing to do, but when I am reading non-fiction for example, oftentimes I get bored.

Sun: … studying in the big framework, that is physics . . . In that framework you can study many subjects in unison, and that seems to be how physics differs from other subjects. . . . I want to be a CEO that can consolidate and lead in different fields but at the same time do physics or experiments in science and get satisfaction from that, and be a manager who can use physics knowledge, on the world stage.

Gyu: To be a leader, you have to have a broad base of knowledge, so I want to study science in school and build some fundamentals, and in college. . . I want to go to business school and study business administration.

Self-Efficacy in Science

The participants had learned formal study methods for science and were very confident in their study strategies. Besides listening to teachers' lectures, they spent a long time studying on their own. The processes of repeated reading of the textbook and reference books, understanding and memorizing important concepts, and solving practice problems were involved. In particular, science students emphasized the need for understanding important concepts from the beginning for further problem solving. When they have difficulty solving problems, they asked for the help of knowledgeable adults or classmates.

> Min: Rather than listening to the teacher's lecture passively in class, I open the book, read it, and after reading each page, think about what I've read and figure out an important part with my finger. And I locate the part in the book again with my finger, and if something seems missing I read that part again. You can memorize [things] easily with that method.

> Jun: So starting in middle school I studied earth science and astronomy on my own at home. There is a book called High-Top, and I read that book every single day to the point where it was torn in places. Then there is a book called Introduction to Astronomy and Astrophysics. That book too, is for reading purposes [rather than problem-solving] and I also read it every day.

> Yun: I review what I learned in class and think about it in different ways. Or, since when you first absorb concepts they may become confusing later on, I try to get a very solid grasp of the concepts when I first learn them.

> Dale: I first go to class to become familiar with the concepts and then solve problems. . .

> Sun: When I don't understand something in class, because I have to take notes and summarize it, I ask questions on the spot or after class, but when solving problems, I think about it on my own for at least two days and if I still don't get it I ask for help from teachers.

> Gyu: I try to retain some basic knowledge in the beginning, and then as I read textbooks or other references, understand how the basic knowledge I've memorized is applied in real life

or how it comes to be from fundamental principles, and then attempt difficult problems or look up things I am particularly curious about and ask my parents or other teachers that I know. I think I study as I do those things.

The students reported that science subjects increased their self-confidence. As they gained successful outcomes such as solving challenging problems and getting good grades or recognition from important others, they became more confident in science, and their self-esteem increased. The effects were particularly vivid in female students. While male students expressed feelings of pride, female students expressed their feeling of ableness. In particular, two female science students, Min and Yun, reported that they wanted to develop a new area in their relevant field.

Min: As I continued to study science though, unlike in Korean or sociology, I got out what I put in, so you start thinking it's a good fit and you start being more interested. Whenever you hear something about science, even walking along the street, you want to go and listen to it so you naturally think you'll end up doing science research. . . . I don’t know about getting a [Nobel Prize], but I think I can discover something new.

Yun: When teachers tell you that something is very difficult, but eventually you figure it out on your own, you think you are capable of eventually understanding that kind of thing, you become confident that you are capable of doing something. . . . I want to create a new field in the direction of molecular biology and dig into it deeper, and create my own path doing research with more passion and responsibility.

Sun: I think it makes me feel more competent from the inside. . . . You like the subject a lot and so you invest more time in it and put in more study and in turn you grow more interested and feel like you grow in substance. . . . it makes you feel more competent and confident and gives you a confidence that you could do it in the future as well, so in that respect I think physics as a subject has considerable meaning for me.

Jun: There have been two occasions where I just felt really good because of earth. My mom really didn't like the fact that I did earth science. Why would you major in that? . . . in middle school, I won a gold medal in the earth science Olympiad. Since then, she has said, "I can understand you have a passion for earth science," and doesn't say the things she used to. . . . Another thing is that . . . gradually at universities . . . as they realize the need for earth science, there are lots of things where you get points for earth science as well. So as I witnessed that, if I had gone with the flow and followed other kids when I was young, doing just physics or math, I would have been worse off, but I've delved into earth science since I was little and now there are doors opening for earth science as well, and it's a bit of an advantage, so I like that too.

Dale: Sometimes when there is something I haven't been able to solve and suddenly I come up with something to solve it, I feel good about myself.

Gyu: As I grow up and compare myself to my younger myself, I think, "Wow! I can solve this kind of problem now, I know these things now," and I pat myself on the back. When I compare myself with myself in the past, I do a little better than my friends around me, so in that respect I sometimes feel good about myself.

Science Is Valuable

The self confidence they had gained through their science learning bolstered their value of science as the important subject for them in a variety of ways. For Jun, earth science was important because it served as a means for him to outperform others in competitions: "I am good at earth science and I want to beat the competition with it." For Gyu, chemistry was important because he could feel intellectual accomplishment as he became more knowledgeable in chemistry: "[Chemistry] is important to me in that it gives me a sense of accomplishment from being able to know a bit more." For Yun, chemistry was important because it was the subject she can do best. So, she felt it was like a companion which would advance her in her future career:

> Most of all it is a subject that I am very confident in and which I like the best, and I want to do something chemistry related in the future, so, in that respect, chemistry feels like a friend that I will have throughout my life, while doing research, making progress, and learning, a friend through that process.

In particular, the science students were keen on science Olympiads because of their impact on their college admission. For them, the admittance to their high schools (i.e., science high schools) meant a successful start for their college admission. To get admitted to the high schools, all of them had prepared for the middle school science Olympiads from at least the seventh grade, and they had eventually succeeded in acquiring a gold medal. The next gateway was to acquire a gold medal in the high school science Olympiads, for which universities will give points when they screen students. An admission to a prestigious university was, in turn, considered necessary for the accomplishment of their distal goals, becoming a distinguished researcher or a CEO. Given the expected merits of receiving an outstanding result in science Olympiads, the four science students were devoting their weekends to preparing for next year's science Olympiads, and among them three students were getting help from a graduate student tutor or a private intensive program.

> Min: As I couldn't get a good result in Korean or in social science even though I tried hard, if I had entered a regular high school, it [college admission] would have been ruined. If I hadn't entered [my current high school], I wouldn't be able to get into any university in Seoul, maybe. . . . Right now it's [my goal is] college admissions. The first step is to get into a good university, and doing good research also depends on that. So, right now my goal is to go to a

good college. . . . I am attending [private] academic enhancement programs [for four hours on weekend] to prepare for the high school Olympiads and also to get a good grade in school math.

Jun: I thought that once I overcame one hurdle, it would be easier to enter a university than it would if I tried in a regular high school. I kept making an effort, thinking that if I succeeded in getting into a science high school, then I had already passed one gateway. . . as they [universities] realize the need for earth science, there are lots of things where you get points for earth science as well. . . . Recently, I got private tutorials from a grad student. And currently I am continuing the tutorials [to prepare for the Olympiads].

Yun: My current goal is to take the gold medal in the national Olympiad. . . [besides] getting a good grade. . . . I go to an academic enhancement program to listen to lectures for the Olympiads [for nine hours each on Saturday and on Sunday].

Dale: The first thing would be to do well in exams, and to understand and be able to apply everything said in class. . . . As a first step, to become familiar with concepts and further on, to do well in exams, I think those are my goals. . . . Yes, most of my classmates [are preparing for the Olympiads]. I am studying for math [Olympiad], too. . . . Sometimes I go to an academic enhancement program, but these days I don't have much time, so I usually study on my own.

On the other hand, non-science students, Sun and Gyu, reported that their engagement in learning science was more influenced by their interest in the subject(s) than their desire to get a good grade, although getting a good grade was also important to them. They seemed to get more out of school science classes than the science students did. It may be that first, they did not attend additional academic enhancement programs or after school programs which would provide instruction beyond formal school courses (contrary to most science students who were attending such programs); and second, they did not have to worry about science Olympiads, which was not their arena.

> Sun: Rather than simply thinking about raising my GPA, I study physics because I like it and that makes me more devoted, but if, in addition to getting self-satisfaction, the results are manifested numerically, then that could be a plus. But I don't think I study because of that. If I wanted to study to get better grades, I don't think I would have invested in studying physics.
>
> Gyu: The most important thing for us is going to college, so I study to get a good GPA. But at least with chemistry, rather than seeking to get good grades—because I like chemistry—when I think I only have to study to level X for school exams, I tend to go further and study to level Y and Z as well. In chemistry, or more generally in science, my interest rather than exams seems to be a bigger factor in my studying.

Influential People

As mentioned previously, the schools that the participants attended were highly selective so that only one or two students from each middle school could be admitted. When asked about influential people for their getting into the current high school or their science learning, interestingly the students' responses differed based on their gender. All the female students gave the opinion that no specific person was very influential except for themselves, although they could list some other people's influences. For Min, a senior student kept encouraging her to study science and math hard so that she was well prepared for getting into a science high school. For Yun, the most influential person was her fourth grade teacher who recommended her to a science gifted program. Sun mentioned various people who influenced her science learning: a middle school science club teacher, a relative who majored in biotechnology, and a famous scientist who had been widely introduced in the media.

Min: I attended a math academy in 7th grade and there was an older guy friend [who was preparing for science high school admissions]. . . . from then on I heard about it from him and even after he went [to a science high school] he kept on telling me about it and I began to think it would be good to go there, and that I should keep on studying for it. . . . I don't think there is anyone else who really influenced me.

Yun: My parents don't work in science. All my relatives are also in law or medicine so I'm the first one in my family to do science. So I don't think there was an influence. . . . you could say I kind of went it alone. . . . There was some teacher who recommended me for a gifted science program in 4th grade. I starting growing interested in science experiments then and that led me to do chemistry Olympiads in middle school and that in turn, to come to science high school. That teacher was probably the first and last person to have influenced me.

Sun: I think the largest influence came from myself. And in middle school the advisor for our science club was a biology teacher, and that teacher very enthusiastically gave us a lot of things to do and led us very well. An older cousin who works in bioengineering . . . when he recommends things it makes me try different things and sometimes find out how it works. I tend to read the news a lot. . . when the media was talking about Hwang Woosuk a lot I became more interested in science. . . being exposed to the media, the news, or the newspaper, makes me more interested than if that hadn't been the case.

In contrast, all male students mentioned their mothers or parents as the most influential for their admission to the current high school. Besides their mothers or parents, the male students recognized the influence of their teachers or other adults. Jun's ninth grade teacher encouraged him to study hard and also provided him with study guides useful for the admission to a science high school. Dale's eighth grade teacher who taught Korean used to discuss scientific topics with him after school and recommended him to enter a science gifted program and to apply for a science high school. When Gyu was a middle school student, his church member, a professor who was researching new materials, encouraged him to pursue chemistry, and his chemistry teachers in the gifted program where he was attending in middle school praised him a lot for his progress in chemistry learning.

> Jun: So, in my case, I was kind of forced by my mom to study math since 3rd grade. . . . then in 9th grade I had a home-room teacher. Before coming to my school, at his previous school, one of his students had entered a science high school. So he told me a lot about what that person did to get into a science high school and hearing that, I pledged to myself [to get in] again and again.

> Dale: There's no need to say my parents influenced me the most. In middle school...my home-room teacher taught Korean, but he was very interested in science and he used to debate things with me after school. He also recommended going to a science high school and gave me a lot of attention in 8th grade because of gifted programs and things like that.

> Gyu: Of course I think my parents were the biggest influence. After them. . . I go to church and there is a professor there that I got to know who does research in revolutionary material science. . . . He suggested studying chemistry which also steered me in this direction, and the teachers at my gifted program complimented me and encouraged me a lot when I was studying chemistry.

Parental Support

Regarding the contribution of their parents to their science learning, female students indicated broad support from their parents rather than direct encouragement or pressure to do science. For example, Min appreciated that her parents allowed her to do what she wanted and supported her financially, although she also reported that her father was good at math and taught her math when she was in seventh and eighth grades. Yun also mentioned that her parents financially supported her and provided transportation so that she could learn science and math at private intensive programs as well as taking her to the library and subscribing to science magazines at her request. In particular, Sun reported her experiences of attending community science events with her parents, in which she was the main actor, and her parents' efforts to provide resources for her science activities; however, her parents' support for her activities was not limited to the science area.

> Min: When I said I wanted to do something they never told me to use that time to do something else. . . . With academic programs too they let me go to the place that I wanted to go so maybe that is why things have worked out well. . . . In 7th and 8th grade dad taught me math, and if I would be reading books mom would come by and ask me what it was about so I wouldn't feel bored.
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> Yun: [What my parents did for my science learning was] driving me to academic programs, paying their fees and buying me science books when I asked for them, getting me to read a lot of books and subscribing to a science magazine for me.
>
> Sun: There was a family event. You know where the kids make gliders. I did that once. I wasn't very good at it and dad helped me a lot. But, it was more than the helping process. To make it we broke the wings of the glider a lot. To make just one we used up components for about twenty. In the middle our family got together to look things up on the internet, to find articles and look up papers so that made it meaningful. Mom, dad and me the three of us participated in this family event. It was a Science Day event that families could participate in. I did it in elementary school. So I did that and another thing was where I was assigned a topic and had to talk about it in front of other people. That was also with families all sitting in

front of me and after I did it I felt very proud. I felt thankful that there were people listening to what I had to say and my family was there so it didn't feel like I was alone and I could talk comfortably so that was why it was good.

In contrast, science male students tended to perceive that their mothers or parents pushed or encouraged them to engage in science and math. Jun started to study math hard from the third grade because his mother pushed him to do so. He heard about science high schools from his mother since his third grade. In the case of Dale's parents, they recommended him to follow a science career, and whenever Dale was not sure of that choice, they encouraged him to gain confidence in the area. In particular, Gyu relied on his mother's expertise in scientific knowledge above all by asking his mother whenever he had difficulty solving science problems. His mother's encouragement supported him practically, by directly teaching him science, as well as emotionally through praise.

Jun: My mother knows a lot about science high schools and foreign language schools and school careers in that direction. So in my case, I was kind of forced by my mom to study math since 3rd grade. . . Around that time I grew up hearing a lot about science high schools without knowing what they were. From my mother.

Dale: My parents, once when I was depressed and wavering whether to go on, encouraged me and told me to keep at it, that I could do it. . . . Dad often says that if he had gone into the sciences he would have been more successful and had more fun, and he advised me to go in that direction.

Gyu: I didn't attend a gifted program from when I was young, but my parents ran an academic program and it was awkward to leave me alone at home so they took me, and my curiosity grew overhearing tidbits of lectures there. . . . Both of my parents majored in chemistry, so since I was young I had a vague sense of awe towards it. . . .At home. . . when I would solve a difficult problem and take it to mom so that she could grade it, she would praise me that I solved it well and I would I feel successful from things like that. . . In my mom's case she has taught all four subjects to high school students beginning after I was born. So I think I've got into the habit of calling my parents and asking them first when I run into something difficult.

Regarding science activities conducted with parents when the students were young, male students remembered that their parents were active in involving them in science activities or science learning. Their mothers were enthusiastic about providing their kindergartner sons with the opportunities to go to science museums or to attend science programs. For their sons' science learning, the mothers provided science practice sheets to supplement their school science learning (for Jun) or science magazines (for Dale). Gyu's parents sat him in their classrooms where they were teaching, from when he was young.

Jun: Perhaps [mom] thought that I had to get interested in science when I was young if I were to grow up and not say no to science but she took me to science museums almost every day. . . . From kindergarten once school breaks started I was always going to science museums, doing science problem sheets and so on.

Dale: I remember when I was young I would go to the community center with my mom and participate in some programs. . . . we went to [science museums] sometimes, in elementary school. In terms of books, we've been subscribing to Science Donga consistently. (Interviewer: Did you want it? Or did mom do it for you?) I wanted it too, both of us did.

Gyu: The Seoul National Hall of Science is near my place. I remember a lot of visits to museums and science museums, and I went with my parents. Something I remember vividly is—it's not related to chemistry—but we'd gone see 'Body the Exhibition.' I didn't know how they'd made dead bodies like that but when I went to see it I thought 'that's what human bodies look like'. I think that's the most memorable moment I had going to a science-related museum in my seventeen years of life.

In contrast to male students who reported their engagement in science activities from kindergarten or elementary school, female students reported that they engaged in a variety of activities when they were young. They did not mention their parents' push or encouragement for a specific area such as science or math. It may be that the female students' parents preferred for their daughters to be well rounded in terms of their education, at least when they were young.

Min: I just played. I did piano and ballet. . . . I didn't do those things [visiting science museums or libraries]. I didn't want to. When they asked me I didn't want to.

Yun: I think we visited museums a lot wherever we went. When we traveled we went to museums and in general they packed in a lot of cultural activity.

Sun: In science as well but in every area my parents allowed me to experience a diverse array of things rather than being focused on one area. I learned a lot of strange weird things when I was young. I learned to paint the Four Gracious Plants [painting with Chinese ink] for a very long time, at a place where they did stuff like that, I also learned swimming for a very long time and my family went traveling to Australia for a while as well. In sports I played netball, which is similar to basketball, and I also learned a lot of instruments. I'd learned piano and a little bit of violin. The piano I did for a very long time, and lots of things like that, and in terms of learning languages as well, you know how you get certificates in Chinese. I got the 2nd highest level in that in elementary school. I studied a lot of different things.

Visions of Science

Most participants mentioned their positive experience with science exhibitions, gifted programs, or science events in elementary or in middle school. When asked to explain their visions of science, they expressed their image of science as benefiting human beings such as curing diseases, preventing global disasters, upgrading living, and solving pollution problems. However, their ideas on what they would accomplish in the field seemed rather abstract, which may suggest that they lacked exposure to real life problem solving or that they lacked understanding of the relationships between the society, technology, and science, in spite of their high ability to solve mathematical or theoretical problems.

> Min: Once I get to college, I'm really interested in neurobiology, so once I get to KAIST [Korean Advanced Institute of Science Technology] I want to study some fundamentals and go abroad to study and do research there. Going into a field that is in its developmental stage you can discover more new things, and it's valuable. And in neurobiology, modern people have a lot of psychiatric diseases and it seems that would be relevant. They do research on the mind, the brain and the mind, and emotions as well and it seems doing those things would be very worthwhile. It seems it would bring concrete benefits and is needed right now.

> Jun: More generally, astronomy works on an enormous scale. You can barely do any experiments. To observe something once and witness it, the time scale is one million years, two million years. So astronomy encompasses the past and the future of humanity. And if we don't succeed in our current research, a long time into the future, as a result of not knowing some piece of astronomy, there could be some damage to the entire human race. . . . So only when we solve certain problems will humans benefit in the future on a very large scale, but if we don't, there could be a huge disaster later on, that seems to be the homework in astronomy.

Yun: [Through chemistry] you can predict things [molecules] that you can't even see and you can put that to use in daily life straightaway and so [I like] those things.

Dale: In science, if you develop a technology or produce good research results, it can be used in real life to upgrade people's lives around the world.

Sun: There are lots of examples where science is used in daily life. And for me physics is particularly. . . among the four subjects physics, chemistry, biology, and earth science, physics seems like a subject where you have all four of them put together.

Gyu: From society's point of view, as we use too much fossil fuel like oil and coal, a lot of byproducts that are harmful to the body as well as earth are produced. But with alternative energy sources that are gaining steam nowadays, you can lead the world without that kind of pollution. Of course you have to have an understanding of other subjects as well but I think you should know some basic things in chemistry to solve that kind of problem. . . . I think basic knowledge in chemistry can be helpful in solving many of the world's problems.

In this vein, science students' deep involvement in science Olympiads, in which students compete to solve very advanced level abstract problems in a time limit, may suggest how science educators and policy makers can improve the current practice towards effective development of advanced students' creativity and research capacities. Some participants, as well as the science curriculum of the schools where science students were attending, indicated that they learned science concepts mainly via teachers' lectures. Given the emphasis on science literacy (e.g., critical thinking, value judgments based on understanding of scientific research, etc.) in science education, it would be more desirable to encourage advanced students, many of whom will be future leaders in the science areas, to spend more time on real life problem solving and extend their understanding of the roles of science for society. Thus, it seems to be necessary for college admission boards to appreciate students' experiences of creative authentic problem solving as much as their outstanding accomplishments in Olympiads.

Summary

Taken together, the advanced students who participated in my interviews were self-regulated, intrinsically and extrinsically motivated, and accomplished learners of science. With great interest, they immersed themselves in understanding science concepts and solving hard practice problems. Such experiences solidified their self-confidence in performing successfully in science, which in turn bolstered their value of science as interesting, important, and useful. In particular, the students who were aspiring for a science degree in college were keen to outperform in exams and science Olympiads, which they considered necessary to gain admission to a prestigious university. The students who wanted to major in business, by contrast, seemed to be more intrinsically motivated at least in school science classes. Regarding personal beliefs and goals, no specific gender differences were found except that female science students tended to be more ambitious for their future career. The females hoped to open a new area in their fields.

The participants seemed to have grown up with parents who were dedicated to their education. Gender differences in parental support were found only in parents' expectation and types of support. Contrary to male students' parents who explicitly encouraged their sons to engage in learning science from an early age, female students' parents seemed to provide their daughters with more opportunities to engage in various activities rather than push their daughters to focus on science activities.

The analyses revealed some problems in the science curriculum of special science high schools and in the current college admissions for science programs in Korea. Compared to their very advanced scientific knowledge and ability to solve abstract problems, their understanding of the relationships between the society, technology, and science seemed to need improvement. Given the advanced students' higher capacity for scientific research, educational practices should focus on nourishing the students' creativity and their ability to find problems in life rather than focus on sieving out students based on their performance on examinations that require highly advanced knowledge and problem solving drills.

CHAPTER VII

DISCUSSION

Motivational Factors

In the study, several important motivational factors related to science learning were measured and compared among academically advanced high school students. They are as follows: self-efficacy (expectancy for success and self-efficacy), value of science (interest, importance, and usefulness), extrinsic goals (performance and ego goals), intrinsic goals (learning and mastery goals), control of learning belief (belief in the importance of effort and strategy for understanding), test-anxiety (anxiety related to science tests), and perception of parental support (discussion, encouragement, expectation, and support of activities). For the measurement of the latent motivational factors, seven scales were used in the study. Among them, six scales were a Korean translation of the motivational part of the MSLQ (Duncan & McKeachie, 2005), and one scale, perception of parental support, was created for the study. The Korean version of the MSLQ entailed somewhat lower internal reliabilities than those provided by Garcia and Pintrich (1995), and two items (cl2: It is my own fault if I don't learn the material in the course; ta2: When I take a test in the course I think about items on other parts of the test I can't answer) had a very low R^2 (.072 and .027, respectively), implying a need to revise them for further use. In addition, the value of science and the intrinsic goals scales lacked discriminant validity. Nonetheless, the instrument measured its target factors well among the Korean advanced high school students when three error covariances were included. In addition, the instrument was partially invariant in both female and male student groups and also in both groups of students who aspire towards science and those who do not. To account for the measurement errors involved, I used structural equation modeling (SEM) and measurement invariance tests. Thus, the comparisons achieved more power than if analysis of variance methods had been used.

As expected, the advanced high school students who aspire to majoring in science were characterized by the motivational factors. In all the factors except for test-anxiety, they reported significantly higher levels than those who opt out of majoring in science. In particular, science students' perception of parental support was 1.3 standard deviations higher. Thus, in the sample, parents played a big role for their children's aspirations for science. However, given the non-significant factor mean differences of the one negative motivational factor, test-anxiety, this factor seems not relevant to science aspirations.

Gender differences were also found in some factors. Female advanced students reported significantly lower levels of self-efficacy, value of science, intrinsic goals, and perception of parental support, although they reported a similar level of extrinsic goals, control of learning belief, and test-anxiety to those of male advanced students. However, given the sample composition with more male students in the science group and more female students in the non-science group, I investigated gender differences among science students for a more meaningful comparison. The investigation found that female science students were not significantly different from their male counterparts in any of the factors except for intrinsic goals. The findings partly support Quihuis (2002). She found no significant gender differences in ability beliefs, task-value, mastery goals, and test-anxiety among the sample of high achieving high school students who aspire towards a college degree in the hard sciences, but she did find gender differences in the factors among the sample of high achieving high school students as a whole.

When female science students were compared with female non-science students, significant differences were manifested in self-efficacy, value of science, intrinsic goals, control of learning belief, and perception of parental support. All of these differences favored the female science student group. Female science students were also lower in test-anxiety to a small to moderate degree; however, the difference did not reach a statistical significance. In particular, the group differences culminated in the perception of parental support, on which female science students were higher by

1.5 standard deviations. This finding is in line with the study of Mau et al. (1995). Mau et al. found that female eighth graders who perceived higher parental expectations tended to aspire towards science or engineering careers.

In the study, correlations among the motivational factors were also examined. As expected, strong associations among self-efficacy, value of science, intrinsic goals, and control of learning belief were found. Parental support was found to correlate with the other factors to a moderate or to a small degree. However, test-anxiety was found to correlate only with self-efficacy (a small negative correlation) and extrinsic goals (a moderate positive correlation). Meece, Wigfield, and Eccles (1990) and Pintrich and DeGroot (1990) were interested in the relationships of test-anxiety with ability beliefs and value. Meece et al. found significant negative correlations between math-anxiety and expectancy and between math-anxiety and importance value of math. By contrast, Pintrich and DeGroot found a negative correlation between test-anxiety and self-efficacy but an insignificant correlation between test-anxiety and intrinsic value, in seventh grade science and English. Thus, the present study is more in line with Pintrich and DeGroot in terms of test-anxiety.

Extra-Curricular Science Activities

The majority of science students and about 60% of non-science students reported they had been engaged in one or more science activities. Their activities were mostly focused on enhancing their academic competence. About 70% of science students and about 40% of non-science students reported attending private academic programs or tutoring. For science students, such extra-learning was for the preparation for the forthcoming science Olympiads as well as for school examinations. The proportion of students who reported engaging in any kind of experimental activities (e.g., gifted programs, individual research, and experimental club) was somewhat larger among non-science students. No conspicuous gender differences in the pattern of science activities were found among science students. However, it was not the case for female science students and female non-science students. The proportion of female science students who were attending private academic programs or tutoring (78%) was higher than the proportion for the overall science group, but the proportion of female non-science students who were attending private academic programs or tutoring (28%) was lower than the proportion for overall non-science group. Taken together, it seemed that science students were relying heavily on private academic programs to keep up their GPAs in science and math or to obtain awards in the science Olympiads. This situation seems to elicit two major concerns: parents' financial burdens and students' overwhelming competition. Students' scientific talents should be exhibited through various creative activities rather than being channeled only to theoretical problem solving.

Self-Concept of Students' Own Strengths for Science

East Asian students have been known to have lower self-confidence in math and science despite of their higher performance in the subjects than their Western counterparts (Chen & Stevenson, 1995). In the study, participants' lower rate of responding to the question about their strength for science (77.7%) than the response rates for the questions about their science activities (87.2%) or their reasons for choosing or opting out of science (95.2%) seems to support the finding. Interestingly, in all the compared groups, the persistent or scrupulous personality was indicated as their own strength by a similar proportion (about 31-38%) of students. Intrinsic interest such as curiosity or interest in science was more frequently indicated by non-science students and female students than science students and male students, respectively. However, the tendency was the opposite for the responses related to ability, challenge-seeking, or passion.

Rationale for Choosing or Opting out of Science

As their rationale for choosing science, students provided the responses related to intrinsic interest the most prevalently and then, the responses related to perceived efficacy or their good performance. The proportion of students who provided an altruistic reason (i.e., for their country's scientific development or for the improvement in human wellbeing) was around six percent in both the male group and the female group, which did not support the findings of Seymour and Hewitt

(1997). These researchers found that altruistic reasons (i.e., attaching their own career goals to a clear social purpose) for choosing science, math, or engineering majors were predominantly represented by women. Regarding the rationale for opting out of majoring in science, interest-related responses were also the most prevalently provided. Then, performance-related responses (e.g., difficulty with and poor performance in science and/or math or better performance in the other subjects) and aptitude-related responses followed in turn. Taken together, the findings support Eccles and Wigfield's (2002) expectancy value theory which explained value (including intrinsic interest) and expectancy for success as major causes for motivated behaviors. However, the findings also suggest that the intrinsic interest value is only relevant to advanced high school students' aspirations for science among the three components (i.e., interest, importance, and usefulness) of value posited by the researchers. Moreover, given the students' exclusion of parents' influence on their major choices, which was found to be the most influential by the instrument administered, the findings warrant caution in the interpretation of the theory: value and expectancy are the most important factors only among students' own attributes.

Interview Study

The interview data informed me of how the participants (four science students and two non-science students) had developed their interest in and value of science. Pleasant learning experiences with science such as achievement of understanding, award winning in science competitions individually or in group, interesting experiments, and participation in science events with their families provided a basis for their identification of themselves with a specific science subject. They were attached to the subjects cognitively and emotionally. In addition, they had external resources that helped them extend their knowledge and make great achievements in the subjects. Private academic programs were the main resources for the science students, and parents or relatives were the main resources for the non-science students. Along with their achievements in the subjects, their self-concept was also enhanced. Students felt pride in themselves, and in particular female science students envisioned a possibility for their further great accomplishment in their careers. Consequently, for the science students, science was considered to be the area that they would pursue for their careers; for non-science students, science was considered to be the area that would equip them for their careers in business.

Their parents' contribution to their science learning was made in multiple ways and also in different ways for the male and female participants. Male students' parents explicitly encouraged their sons to engage in science and tried to provide their sons with learning opportunities in math and science from their early elementary school years. However, female students' parents seemed to have provided their daughters with the opportunities to engage in various activities rather than pushing their daughters to focus on science activities. After the children entered middle school, the parents helped them to extend their knowledge and prepare for competition by providing external resources or by working together with their children. Interestingly, however, only male students reported that their parents' emotional support (understanding, encouragement, and praises) was helpful for their learning and choosing science. Given the body of research on women majoring in science or pursuing science careers has found that familial encouragement played a significant role in women's persistence in science (e.g., Rayman & Brett, 1995; Zeldin & Pajares, 2000), this finding was unexpected. It may be that the female students did not yet recognize those social barriers that may hamper their later advancement in science careers. At some time, their parents' emotional support may become essential for their persistence in science.

The Aspirations for Science of Advanced Students

The study established a structural equation model to explain science aspirations. In the model, the three predictors, perception of parental support, value of science, and self-efficacy, as a whole, explained the variance in science aspirations by 66%. Perception of parental support had a large effect, and value of science had a small effect on the aspirations. However, no significant effect of self-efficacy on the aspirations was found. In the model, value of science was specified to be affected by perception of parental support and self-efficacy, in turn. In this regard, the effect of parental support was small, and the effect of self-efficacy was moderate.

Some gender differences in the model parameters were found. As expected, the effect of the parental support factor on the aspirations was larger for female students than for male students (effect size difference = .21). This finding supports Mau et al. (1995) who found significant effects of familial supports on female eighth graders' aspirations for science careers. In developing value of science, male students were significantly affected by self-efficacy to a moderate degree and by parental support to a small degree. By contrast, female students were affected by self-efficacy to a large degree, but they were not significantly affected by parental support. It may be that male students develop their value of science with both the support of their parents and with their own sense of efficacy in science, while female students develop their value of science with their sense of efficacy, regardless of their perception of parental support.

Practical Implications

The present findings inform parents and educators of how to help their talented children develop aspirations for science and advance in the field. Above all, parents need to provide them with the opportunities to have positive experiences with science from as early as elementary school, so that they can develop more interest and efficacy in science. Involvement in science exhibitions, family science events, and science experiments as well as supplemental learning in math and science can be helpful. In addition, parents and teachers of advanced students who are already aspiring to science need to encourage the students to pursue deeper understanding of scientific concepts and more challenging projects rather than being focused on getting good course grades. This is particularly relevant to female students given the finding of their lower intrinsic goals. Finally, the study has implications for science students' extra-curricular science activities. Most of the science students (70%) were found to attend private science academic programs to prepare for the science Olympiads and/or to keep up high grades in classes, which would eventually help their college admissions. This situation arouses two main concerns. First, the great expenditure of family income on private education tuition is a great burden to parents in Korean society. Second, students are vulnerable to excessive competition and stress as most of them are competing in the science Olympiads. College admissions should consider the reality and readjust their conventions, which currently place too much emphasis on outstanding performance in abstract problem solving such as the science Olympiads. Given the tremendous effect college admission has on high school education, colleges and universities have both the capacity and the responsibility to encourage advanced students to engage in activities that are more relevant to their own experiences and environments. They should not foster the track that sieves out high ability students who cannot pass the gateway (the science Olympiads). In the current situation, most students require extra instruction to pass through this gateway, which places a heavy financial burden on their parents.

Theoretical Implications

The study has theoretical implications. First, it extends the expectancy-value theory by finding a direct effect of parents on aspirations for science. In fact, it found that parental support has a larger effect on students' aspirations for majoring in science than value or ability beliefs. Second, the study supports the views of Elliot and Harackiecz (1996) who argued for the positive effects of performance approach goals on achievement behaviors and Pintrich (2000) who argued for the positive effects of multiple goals of performance and mastery. The present study found that advanced high school students who aspire towards majoring in science have higher extrinsic and intrinsic goals compared to those who opt out of majoring in science. Third, the study contributes to the literature on gender differences in science motivation. Previous research has not been consistent in this matter. Depending on the samples used, females' science motivation was claimed either to be less favorable than or comparable to their male counterparts'. The study provided clearer explanations of gender differences by focusing on a relatively homogeneous sample: academically advanced female and male high school students, some of whom aspired towards a college science degree and some who did not. Moreover, by using SEM rather than the analyses of variance methods, the statistical analyses accounted for the errors involved in the measurement of latent motivational constructs and thus could provide more powerful analyses. Furthermore, by incorporating the tests of measurement invariance in finding group differences, the study provided more accurate findings. Finally, the study contributed to the literature on students' science aspirations. It provided not only a statistical model of science aspirations but also detailed descriptions and explanations of the aspirations by incorporating qualitative methods as well as statistical methods.

Limitations

First, the data were collected around three months after the sample students entered their high schools. The admission to the school itself meant a successful start for their future goal, admission to a prestigious university. Accordingly, the study is considered to mainly illuminate the beliefs and experiences of advanced students who were starting their high school with high expectations. As a result, the voices of those students who were already losing their confidence and considering withdrawing from academic endeavors were not heard. Thus, the findings should not be generalized to all the advanced students who enrolled for special high schools for the talented. Second, the statistical estimations in the study may be unstable given the comparatively small sample size to the number of estimated parameters and given the unbalanced sample sizes across comparison groups. Third, given the partial invariance of the instrument across the groups interested, the group differences in the factor means might have been influenced by the differences in measurement properties of some items.

Future Studies.

The study suggests some directions for future research. First, in the school environment in which all advanced students compete for outstanding outcomes in the national competitions as well as in course examinations, not all students can be successful. Investigation of how the students keep their motivational beliefs and aspirations for science as they advance in high school will provide suggestions for effective educational practices. Next, given the large effect of parental support on science aspirations found in the study, future research on science motivation should consider including this factor. In addition, future research whose participants have differing family backgrounds, with respect to social economic status and ethnicity, and which incorporates qualitative methods will be able to illuminate the various ways parents affect their children's science aspirations. Finally, future research that investigates extra-curricular science activities engaged in by advanced high school students from differing countries will inform educational policy makers of how to effectively support talented students' accomplishments in science.

REFERENCES

Ames, C. (1992). Classrooms: goals, structures, and student motivation. *Journal of Educational Psychology, 84,* 261-271.

Astin, A. W., & Nichols, R. C. (1964). Life goals and vocational choice. *Journal of Applied Psychology, 48,* 50-58.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review, 64*, 359-372.

Baker, D., & Leary, R. (1995). Letting girls speak out about science. *Journal of Research in Science Teaching, 32,* 3-27.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewook, NJ: Prentice-Hall Inc.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44,* 1175-1184.

Bandura, A. (2006). Adolescent development from an agentic perspective. In F. Pajares & T. Urdan (Eds.), *Adolescence and education: Vol. 6. Self efficacy beliefs of adolescents* (pp. 1-44). Greenwich, CT: AIP-Information Age Publishing.

Bong, M. (1996). Problems in academic motivation research and advantages and disadvantages of their solutions. *Contemporary Educational Psychology, 21,* 149-165.

Buyukozturk, S., Akgun, O. E., Ozkahveci, O., & Demirel, F. (2004). The validity and reliability study of the Turkish version of the Motivated Strategies for Learning Questionnaire. *Educational Sciences: Theory & Practice, 4,* 231-239.

Chen, C., & Stevenson, H. W. (1995). Motivation and mathematics achievement: A comparative study of Asian-American, Caucasian-American, and East Asian high school students. *Child Development, 66,* 1215-1234.

Clark, L. A., Watson, D. (1995). Constructing validity: Basic issues in objective scale development. *Psychological Assessment, 7,* 309-319.

Dai, D. Y., Moon, S. M., & Feldhusen, J. F. (1998). Achievement motivation and gifted students: A social cognitive perspective. *Educational Psychologist, 33*, 45-63.

Davenport, M. A. (2003). Modeling motivation and learning strategy use in the classroom: An assessment of the factorial, structural, and predictive validity of the motivated strategies for learning questionnaire. *Dissertation Abstracts International, 64* (2-A), 394.

DeBacker, T. K., & Nelson, R. M. (2000). Motivation to learn science: Differences related to gender, class type, and ability. *Journal of Educational Research, 93*, 245-254.

DeCarlo, L. T. (1997). On the meaning and use of kurtosis. *Psychological Methods, 3,* 292-307.

Deemer, S. A. (2004). Classroom goal orientation in high school classrooms: Revealing links between teacher beliefs and classroom environments. *Educational Research, 46*, 73-90.

Duncan, T. G., & McKeachie (2005). Making of the Motivated Strategies for Learning Questionnaire. *Educational Psychologist*, 40, 117-128.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-273.

Eccles, J. C., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and Achievement motives* (pp. 75-146). San Francisco, CA: W. H. Freemen.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*, 215-225.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109-132.

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (5th ed., pp. 1017-1095). New York: John Wiley & Sons, Inc.

Elliot, A. J., & Harackiewicz, J. M. (1994). Goal setting, achievement orientation, and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology, 66,* 968-980.

Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology, 70,* 461-475.

Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology, 54*, 5-12.

Enman, M., & Lupart, J. (2000). Talented female students' resistance to science: an exploratory study of post-secondary achievement motivation, persistence, and epistemological characteristics. *High Ability Studies, 11,* 161-178.

Epstein, J. (1989).Family structures and student motivation: a developmental perspective. In C. Ames & R. Ames (Eds.), *Research on motivation in education: Vol. 3. Goals and cognitions* (pp. 259-295). San Diego, CA: Academic Press.

Farmer, H. S., Wardrop, L., & Rotella, S. C. (1999). Antecedent factors differentiating women and men in science/nonscience careers. *Psychology of Women Quarterly, 23*, 763-780.

Fehrmann, P. G., Keith, T. Z., & Reimers, T. M. (1987). Home influence on school learning: Direct and indirect effects of parental involvement on high school grades. *Journal of Educational Research, 80,* 330–337.

Gallagher, J. J. (1993). An intersection of public policy and social science: Gifted students and education in mathematics and science. In L. A. Penner, G. M. Batsche, H. M. Knoff, & D. L. Nelson (Eds.), *The Challenge in mathematics and science education* (pp. 15-47), Washington, DC: American Psychological Association.

Garcia, T., & pintrich, P. R. (1995, April). *Assessing students' motivation and learning strategies: the Motivated Strategies for Learning Questionnaire*. Paper presented at the annual meeting of the American Education Research Association, San Francisco, CA.

George, R., & Kaplan, D. (1998). A structural model of parent and teacher influences on science attitudes of eighth graders: evidence from NELS: 88. *Science Education*, 82, 93-109.

Gillham, B. (2000). *The research interview*. London: TJ International.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2007). Nonscience majors learning science: a theoretical model of motivation. *Journal of Research in Science Teaching, 44*, 1088-1107.

Gonzalez, R., & Griffin, D. (2001). Testing parameters in structural equation modeling: Every "One" matters. *Psychological Methods, 6*, 258-269.

Greene, B. A., & DeBacker, T. K. (2004). Gender and orientations toward the future: Links to motivation. *Educational Psychology Review, 16*, 91-120.

Greene, B. A., DeBacker, T. K., Ravindran, B., & Krows, A. J. (1999). Goals, values, and beliefs as predictors of achievement and effort in high school math classes. *Sex Roles, 40*, 421-458.

Hackett, G., & Betz, N. E. (1981). A self-efficacy approach to the career development of women. *Journal of Vocational Behavior, 18*, 326-339.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*, 261-273.

Hancock, G. R. (1997). Structural equation modeling methods of hypotheses testing of latent variable means. *Measurement & Evaluation in Counseling & Development, 30*, 91-105.

Hancock, G. R. (2001). Effect size, power, and sample size determination for structured means modeling and MIMIC approaches to between-groups hypothesis testing of means on a single latent construct. *Psychometrika, 66*, 373-388.

Heller, K. A., & Ziegler, A. (1996). Gender differences in mathematics and the sciences: Can attributional retraining improve the performance of gifted females? *Gifted Child Quarterly, 40*, 200-210.

Hollinger, C. L. (1983). Self-perception of the career aspirations of mathematically talented female adolescents. *Journal of Vocational Behavior, 22*, 49-62.

Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods, 3,* 424-453.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55.

Keith, T. Z., Keith, P. B., Troutman, G. M., Bickley, P. G., Trivette, P. S., & Singh, K. (1993). Does parental involvement affect eighth grade students' achievement? Structural analysis of national data. *School Psychology Review, 22,* 474–496.

Kim, U., & Park, Y. (2006). Factors influencing academic achievement in relational cultures. In F. Pajares & T. Urdan (Eds.), *Adolescence and education: Vol. 6. Self efficacy beliefs of adolescents* (pp. 267-285). Greenwich, CT: AIP-Information Age Publishing.

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York: Guilford.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. *Journal of counseling Psychology, 31*, 356-362.

Lent, R. W., Brown, S. D., Larkin, K. C. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology, 33,* 265-269.

Li, A. K. F., & Adamson, G. (1995). Motivational patterns related to gifted students' leaning of mathematics, science and English: an examination of gender differences. *Journal for the Education of the Gifted, 18*, 284-297.

Marsh, H. W., Hau, K., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling, 11,* 320-341.

Mau, W., Domnick, M., & Ellsworth, R. A. (1995). Characteristics of female students who aspire to science and engineering or homemaking occupations. *Career Development Quarterly, 43,* 323-337.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82,* 60-70.

Mueller, C. M., & Dweck, C. S. (1998). Praise for intelligence can undermine children's motivation and performance. *Journal of Personality and Social Psychology, 75*, 33-52.

Nicholls, J. G. (1984). Achievement motivation: conceptions of ability, subjective experience, task choice, and performance. *Psychological Review, 91*, 328-346.

Nicholls, J. G., Cobb, P., Wood, T., Yackel, E., & Patashnick, M. (1990). Assessing students' theories of success in mathematics: Individual and classroom differences. *Journal for Research in Mathematics Education, 21*, 109-122.

Nolen, S. B. (2003). Learning environment, motivation, and achievement in high school science. *Journal of Research in Science Teaching, 40*, 347-368.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25,* 1049-1079.

Pajares, F. (1997). Current directions in self-efficacy research. In M. Maehr & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (Vol. 10., pp. 1-49). Greenwich, CT: JAI Press.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Pintrich, P. R. (2000). Multiple goals, multiple pathways: the role of goal orientation in learning and achievement. *Journal of Educational Psychology, 92*, 544-555.

Pintrich, P. R. (2000b). An achievement goal theory perspective on issues on motivation terminology, theory, and research. *Contemporary Educational Psychology, 25*, 92-104.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33-40.

Pintrich, P. R., Smith, D. A. F., Garcia, T., & MaKeachie, W. J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measurement*, *53*, 801-813.

Quihuis, G. (2002). *Understanding the factors that influence high science achievers' academic choices and intent to pursue or opt out of hard sciences*. Unpublished doctoral dissertation, Stanford University, California.

Ratelle, C. F., Larose, S., Guay, F., & Senécal, C. (2005). Perceptions of parental involvement and support as predictors of college students' persistence in a science curriculum. *Journal of Family Psychology, 19*, 286-293.

Rayman, P., & Brett, B. (1995). Women science majors: what makes a difference in persistence after graduation? *Journal of Higher Education, 66*, 388-412.

Rejskind, G. (1993, February). *Choosing science*. Paper presented at Esther Katz Rosen Symposium on the Psychological Development of Gifted Children, Lawrence, KS.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, Colorado: Westview Press.

Shen, C. (2005). How American middle schools differ from schools of five Asian countries: Based on cross-national data from TIMSS 1999. *Educational Research and Evaluation, 11,* 179-199.

Sieglen, J., & Trost, Gunter (1998). Prediction of outstanding achievement in the natural sciences. *Gifted Education International, 13*, 106-112.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: a longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42,* 70-83.

Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education, 82*, 111-125.

Smith, J. L., Sansone, C., & White, P. H. (2007). The stereotyped task engagement process: the role of interest and achievement motivation. *Journal of Educational Psychology, 99,* 99-114.

Stake, J. E. (2006). The critical mediating role of social encouragement for science motivation and confidence among high school girls and boys. *Journal of Applied Social Psychology, 36,* 1017-1045.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613- 629.

Steenkamp, J. E. M., & Baumgartner, H. (1998). Assessing measurement invariance in cross-national consumer research. *Journal of Consumer Research, 25*, 78-90.

Subotnik, R. F. (1988). Factors from the structure of intellect model associated with gifted adolescents' problem finding in science: Research with Westinghouse Science Talent Search winners. *Journal of Creative Behavior, 22*, 42-54.

Thompson, M. S., & Green, S. B. (2006). Evaluating between-group differences in latent variable means. In G. R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling* (2nd ed., pp. 119-169). Greenwich, CT: IAP.

Urdan, T., Midgley, C., & Anderman, E. M. (1998). The role of classroom goal structure in students' use of self-handicapping strategies. *American Educational Research Journal, 35*, 101-122.

Weiner, B. (1994). Integrating social and personal theories of achievement striving. *Review of Educational Research, 64*, 557-573.

Wigfield, A., & Eccles, J. C. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25,* 68-81.

Woolnough, B. E., & Guo, Y. (1997). Factors affecting student choice of career in science and engineering: parallel studies in Australia, Canada, China, England, Japan and Portugal. *Research in Science & Technological Education, 15*, 105-122.

Zeldin, A. L. & Pajares, F. (2000). Against the odds: self efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Journal, 37*, 215-246.

Zusho, A., & Pintrich, P. R. (2003). Skill and will: the role of motivation and cognition in the learning of college chemistry. *International Journal of Science Education, 25*, 1081-1094.

APPENDICES

APPENDIX A

QUESTIONNAIRES

Appendix A1. Questionnaire (English Version)

Questionnaire

■ Your responses on this questionnaire will be used to better understand your thinking and feeling related to learning science.

Think about your favorite science courses. Please respond to each of the following statements according to your thoughts on or experiences with ***one of your favorite science courses*** with reference to the anchors provided below.

Not at all true of me		Not True		Neutral		Somewhat True		Absolutely True of me
1	2	3	4	5	6	7		

1. In the science course, I prefer course material that really challenges me so I can learn new things.	1	2	3	4	5	6	7
2. If I study in appropriate ways, then I will be able to learn the material in the course.	1	2	3	4	5	6	7
3. When I take a test in the course I think about how poorly I am doing compared with other students.	1	2	3	4	5	6	7
4. I think I will be able to use what I learn in the course in other courses.	1	2	3	4	5	6	7
5. I believe I will receive an excellent grade in the course.	1	2	3	4	5	6	7
6. I'm certain I can understand the most difficult material presented in the readings for the course.	1	2	3	4	5	6	7
7. Getting a good grade in the course is the most satisfying thing for me right now.	1	2	3	4	5	6	7
8. When I take a test in the course I think about items on	1	2	3	4	5	6	7

other parts of the test I can't answer.

9. It is my own fault if I don't learn the material in the course.	1	2	3	4	5	6	7
10. It is important for me to learn the course material in the course.	1	2	3	4	5	6	7

Not at all true		Not True		Neutral		Somewhat True	Absolutely True
1	2	3	4	5	6	7	

11. The most important thing for me right now is improving my overall grade point average, so my main concern in the course is getting a good grade.	1	2	3	4	5	6	7
12. I'm confident I can learn the basic concepts taught in the course.	1	2	3	4	5	6	7
13. If I can, I want to get better grades in the course than most of the other students.	1	2	3	4	5	6	7
14. When I take tests in the course, I think of the consequences of failing.	1	2	3	4	5	6	7
15. I'm confident I can understand the most complex material presented by the teacher in the course.	1	2	3	4	5	6	7
16. In a course like it, I prefer course material that arouses my curiosity, even if it is difficult to learn.	1	2	3	4	5	6	7
17. I am very interested in the content area of the course.	1	2	3	4	5	6	7
18. If I try hard enough, then I will understand the course material.	1	2	3	4	5	6	7
19. I have an uneasy, upset feeling when I take an exam in the course.	1	2	3	4	5	6	7
20. I'm confident I can do an excellent job on the assignments and tests in the course.	1	2	3	4	5	6	7
21. I expect to do well in the course.	1	2	3	4	5	6	7
22. The most satisfying thing for me in the course is trying	1	2	3	4	5	6	7

to understand the content as thoroughly as possible.

23. I think the course material in the class is useful for me to learn.	1	2	3	4	5	6	7
24. When I have the opportunity in the course, I choose course assignments that I can learn from even if they don't guarantee a good grade.	1	2	3	4	5	6	7
25. If I don't understand the course material, it is because I didn't try hard enough.	1	2	3	4	5	6	7
26. I like the subject matter of the course.	1	2	3	4	5	6	7
27. Understanding the subject matter of the course is very important to me.	1	2	3	4	5	6	7
28. I feel my heart beating fast when I take an exam in the course.	1	2	3	4	5	6	7
29. I'm certain I can master the skills being taught in the course.	1	2	3	4	5	6	7
30. I want to do well in the course because it is important to show my ability to my family, friends, or others.	1	2	3	4	5	6	7
31. Considering the difficulty of the course, the teacher and my skills, I think I will do well in the course.	1	2	3	4	5	6	7

■ The following items are to learn how your parents (guardian) think and believe about your science learning. Please select the response that corresponds to your perceptions the most.

Not at all True of me		Not true		Neutral	Somewhat True	Absolutely True of me
1	2	3	4	5	6	7

32. I have been influenced greatly in my science learning from a role model in my family.	1	2	3	4	5	6	7
33. My parents expect me to achieve high grades in the science courses.	1	2	3	4	5	6	7

34. My parents often discuss with me my progress in the science courses.	1 2 3 4 5 6 7
35. My parents have strongly encouraged me to have a science career in the future.	1 2 3 4 5 6 7
36. My parents have sincerely supported my participation in science extracurricular activities.	1 2 3 4 5 6 7
37. In college, I will major in science, math, or engineering.	1 2 3 4 5 6 7

38. Please describe the major science extracurricular activities you have been involved with, including the type of activity and your weekly or monthly time commitment.

39. What are your strengths that help you succeed in the sciences?

40-1. If you are going to major in science, math, or engineering in college, can you briefly explain why?

40-2. If you are not going to major in science, math, or engineering in college, can you briefly explain why?

■ Please provide your demographic information by filling out ( ) and by checking in □ that is most relevant to you.

- favorite science subjects: (   )
- future career: (   )
- How many science classes have you had in high school? (   )
- Gender: Female □ Male □
- Grade: Freshman □ Sophomore □ Junior □ Senior □
- Ethnicity: Asian □ Black □ Hispanic □ White □ Other □
- Father's the Highest Education

  Other □ High School Graduate □

  College Degree □ Graduate School Degree □

- My father has (had) a career in science Yes □ No □
- Mother's the Highest Education

  Other □ High School Graduate □

  College Degree □ Graduate School Degree □

- My mother has (had) a career in science. Yes □ No □

Thank you very much for completing this questionnaire!
Muchas gracias!

Appendix A2. Questionnaire (Korean Version)

설문지

■이 설문지는 과학 학습과 관련된 학생들의 생각과 느낌을 이해하기 위한 것입니다. 먼저, 여러분이 좋아하는 특정 과학 과목을 선택한 후, 그 과목에 대한 개인적인 생각과 경험이 각 진술들과 일치하는 정도에 따라, 아래의 수직선을 참고로 하여 한 개의 숫자를 선택해 주세요.

나는 전혀 그렇지 않다 Not at all true of me		Not True		그저 그렇다 Neutral		Somewhat True		매우 그러하다 (전적으로 동의함) Absolutely True of me
1		2	3	4	5	6		7

1. 그 과목에서는 내가 새로운 것을 배울 수있는 정말로 도전적인 수업 내용 (자료)을 선호한다.	1	2	3	4	5	6	7
2. (나의 경우에는) 적절한 방법으로 공부한다면, 그 과목의 수업 내용 (자료)들을 이해할 수 있을 것이다.	1	2	3	4	5	6	7
3. 그 과목의 시험을 볼 때에는, 다른 학생들과 비교해서 내가 얼마나 부진한지를 생각하게 된다.	1	2	3	4	5	6	7
4. 나는 그 시간에 배운 것을 다른 과목 시간에도 이용할 수 있다고 생각한다.	1	2	3	4	5	6	7
5. 나는 그 과목에서 우수한 성적을 받을 것이라고 믿는다.	1	2	3	4	5	6	7
6. 나는 그 과목 수업에서 제시되는 가장 어려운 읽기 자료들도 이해할 수 있다고 확신한다.	1	2	3	4	5	6	7
7. 그 과목에서 좋은 성적을 받는 것이 현재의 나에게 있어서는 가장 만족스러운 것이다.	1	2	3	4	5	6	7
8. 그 과목의 시험 문제를 풀 때에는, 그 시험의 다른 부분에서 내가 답하지 못했던 문항들에 대해 생각하게 된다.	1	2	3	4	5	6	7
9. 그 과목의 내용을 배우지 못한다면, 그것은 내 자신의 탓이다.	1	2	3	4	5	6	7

10. 나에게 있어서, 그 교과 내용 (자료)을 배우는 것은 중요하다.	1	2	3	4	5	6	7

전혀 그렇지 않다 Not at all true of me	그렇지 않다 Not True	그저 그렇다 Neutral	그런 편이다 Somewhat True	매우 그러하다 (전적으로 동의함) Absolutely True of me

1	2	3	4	5	6	7

11. 지금 나에게 가장 중요한 것은 나의 학점을 향상시키는 것이기 때문에, 그 과목 시간의 내 주요 관심은 좋은 성적을 받는 것이다.	1	2	3	4	5	6	7
12. 나는 그 과목에서 가르쳐지는 기본 개념들을 배울 자신이 있다.	1	2	3	4	5	6	7
13. 할 수 있다면, 그 과목에서 대부분의 다른 학생들보다 더 좋은 성적을 거두고 싶다.	1	2	3	4	5	6	7
14. 그 과목의 시험을 볼 때에는, 실패한 후의 결과에 대해 생각한다.	1	2	3	4	5	6	7
15. 나는 그 과목의 선생님이 제시하시는 가장 복잡한 수업 내용 (자료)도 이해할 수 있다고 자신한다.	1	2	3	4	5	6	7
16. 그 과목과 같은 경우에는, 비록 배우기 어렵더라도 내 호기심을 불러 일으키는 수업 자료들을 나는 선호한다.	1	2	3	4	5	6	7
17. 나는 그 과목의 수업 내용에 매우 흥미가 있다.	1	2	3	4	5	6	7
18. 충분히 열심히 한다면, 나는 그 과목의 수업 내용 (자료)들을 이해할 수 있을 것이다.	1	2	3	4	5	6	7
19. 그 과목의 시험을 볼 때에는 불안하고 기분이 좋지 않다.	1	2	3	4	5	6	7
20. 나는 그 과목의 과제나 시험을 우수하게 해낼 자신이 있다.	1	2	3	4	5	6	7
21. 나는 그 과목에서 잘 할 것이라고 예상한다.	1	2	3	4	5	6	7

22. 나는 그 과목에서 가능한한 철저하게 내용을 이해하려고 노력할 때 가장 만족감을 느낀다. 1 2 3 4 5 6 7

23. 그 과목 자료들은 내가 배우는데 유용하다. 1 2 3 4 5 6 7

24. 그 과목에서는 선택의 기회가 주어진다면, 비록 좋은 성적이 보장되지는 않더라도 무엇인가를 배울 수 있는 과제를 나는 선택한다. 1 2 3 4 5 6 7

25. 그 과목의 수업 내용이 이해가 안 된다면, 그것은 내가 충분히 노력하지 않았기 때문이다. 1 2 3 4 5 6 7

26. 나는 그 교과의 내용들을 좋아한다. 1 2 3 4 5 6 7

27. 그 교과의 내용들을 이해하는 것은 나에게 매우 중요하다. 1 2 3 4 5 6 7

28. 그 과목의 시험을 볼 때에는 내 심장이 빠르게 뛰는 것을 느낀다. 1 2 3 4 5 6 7

29. 나는 그 과목에서 가르치는 실기(skills)들을 숙달할 수 있다고 확신한다. 1 2 3 4 5 6 7

30. 내 능력을 가족이나 친구들 또는 다른 사람들에게 보이는 것이 중요하기 때문에 나는 그 과목에서 잘 하기를 원한다. 1 2 3 4 5 6 7

31. 그 과목의 난이도, 교사, 그리고 나의 실력을 고려할 때, 나는 그 과목에서 잘 할 것이라고 생각한다. 1 2 3 4 5 6 7

■ 여러분이 느끼고 있는 여러분의 부모님 (보호자)의 과학 학습에 대한 생각이나 소신을 알아보고자 합니다. 앞에서와 같은 방법으로 응답해 주시기 바랍니다.

1	2	3	4	5	6	7
전혀 그렇지 않다 Not at all True of me	그렇지 않다		그저 그렇다 Neutral	그런 편이다		매우 그러하다 (전적으로 동의함) Absolutely True of me

32. 내 가족 중에는 나의 과학 학습의 역할 모델 (모범)이 되는 분이 있어 나에게 많은 영향을 주셨다. 1 2 3 4 5 6 7

33. 나의 부모님은 내가 과학에서 우수한 성적을 거둘 1 2 3 4 5 6 7

것이라고 믿고 계신다.

34. 부모님과 나는 과학 교과에서의 나의 성취에 관하여 자주 논의한다.	1	2	3	4	5	6	7
35. 나의 부모님께서는 내가 장래에 과학 관련 직업을 가질 것을 강력하게 권하신다.	1	2	3	4	5	6	7
36. 나의 부모님께서는 내가 과학 과외 활동에 참여할 수 있도록 최선을 다해 뒷바라지 하신다.	1	2	3	4	5	6	7
37. 나는 대학에서 과학이나, 공학, 또는 수학을 전공할 것이다.	1	2	3	4	5	6	7

■ 다음 질문에 대해 간단히 설명해 주십시요.

38. 여러분이 현재 참여하고 있거나 최근까지 해 왔던 과학 과외 활동에 대해 간단히 묘사해 주세요 (종류, 활동 시간).

39. 여러분의 어떤 성격 또는 자질이 여러분이 과학을 잘 하는데에 도움이 됩니까?

40-1. 만약 여러분이 대학에서 과학 (또는 공학, 수학)을 전공하고자 한다면, 그 이유에 대해 설명해 주세요.

40-2. 만약 여러분이 대학에서 과학 (또는 공학, 수학)을 전공하지 않겠다고 생각한다면, 그 이유를 설명해 주세요.

■ 여러분의 인적 사항을 간단히 써 주시고, □가 있는 곳에는 V 로 표시해 주시기 바랍니다.

- 좋아하는 과학 과목 (들): ( )
- 장래 직업: ( )
- 고등학교에서 수강하고 있는 전체 과학 과목 수는? ( )
- 성별: 여성 □ 남성 □
- 학년: 10 학년 □ 11 학년 □ 12 학년 □
- 아버지의 최고 학력
  고졸□ 대졸□ 대학원졸□
- 나의 아버지는 과학 관련 직업에 종사하신(셨)다. 예 □ 아니요 □
- 어머니의 최고 학력
  고졸□ 대졸□ 대학원졸□
- 나의 어머니는 과학 관련 직업에 종사하신(셨)다. 예 □ 아니요 □

설문지를 완성해 주셔서 매우 감사합니다!
Thank you very much for completing this questionnaire!
Muchas gracias!

APPENDIX B

A SAMPLE OF INTERVIEW QUESTIONS

1. Describe your most enjoyable experience in a science course.

2. What aspects of the subject do you like?

3. In what ways is the subject important to you?

4. Describe how you study that subject.

5. Describe the times when you felt good about yourself in the science course?

6. When do you feel successful in your science classes? Describe an example of when that happened to you.

7. What are you most interested in, in your science classes?

8. In what ways is learning science valuable to you?

9. Describe your goals for your learning in the science classes you are now enrolled in.

10. How do you think science is distinguished from other subjects?

11. Explain why you chose to enter this science academy?

12. Tell me about some people who influenced you to enter this academy. In what ways did the person influence your decision?

13. Describe your science extracurricular activities that you are involved in.

14. Describe your early childhood experiences in science.

15. How have your parents influenced you regarding science learning?

16. Describe any early science experiences you enjoyed with your parents.

17. Please tell me about your plans after high school.

APPENDIX C

VARIABLE COVARIANCES, MEANS, AND STANDARD DEVIATIONS (WHOLE SAMPLE)

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	TV1	TV2	TV3	TV4	TV5	TV6
SE1	1.37													
SE2	.97	1.89												
SE3	.43	.57	.84											
SE4	.94	1.49	.64	2.08										
SE5	.80	.87	.50	1.00	1.34									
SE6	.91	.88	.49	.95	1.01	1.34								
SE7	.55	.82	.40	.85	.74	.73	1.73							
SE8	.86	.90	.45	1.02	.89	.94	.70	1.30						
TV1	.49	.52	.33	.48	.38	.46	.47	.49	1.55					
TV2	.36	.48	.31	.55	.41	.51	.51	.47	.39	1.30				
TV3	.56	.67	.47	.86	.65	.72	.69	.70	.51	.69	1.27			
TV4	.45	.60	.36	.67	.54	.56	.49	.48	.55	.56	.73	1.21		
TV5	.53	.63	.47	.73	.61	.63	.62	.63	.38	.57	.85	.53	1.10	
TV6	.44	.50	.36	.57	.47	.55	.62	.52	.31	.77	.70	.58	.67	1.25
EG1	.21	.53	.22	.41	.26	.27	.30	.25	.15	.62	.38	.32	.28	.51
EG2	-.04	.01	.05	-.10	-.07	-.06	-.20	-.08	-.08	.12	-.14	.03	-.17	.04
EG3	.22	.23	.28	.30	.23	.27	.09	.21	.15	.24	.27	.23	.21	.19
EG4	.13	.19	.08	.12	.12	.22	.27	.41	.13	.19	.02	.00	.00	.19
IG1	.47	.67	.38	.66	.54	.54	.62	.57	.49	.47	.72	.47	.62	.48
IG2	.54	.83	.43	.96	.52	.57	.69	.64	.43	.56	.90	.61	.68	.56
IG3	.33	.39	.30	.42	.39	.45	.34	.35	.38	.47	.44	.48	.34	.50
IG4	.17	.63	.22	.66	.44	.43	.62	.45	.34	.41	.61	.53	.65	.50
CL1	.32	.48	.30	.49	.30	.33	.18	.36	.27	.15	.27	.17	.25	.21
CL2	.04	.37	.17	.30	.14	.10	.30	.25	.11	.56	.31	.30	.32	.44
CL3	.39	.54	.36	.62	.43	.45	.35	.49	.25	.31	.53	.38	.46	.36
CL4	.19	.34	.15	.33	.22	.26	.27	.38	.16	.26	.27	.25	.43	.33
TA1	-.42	-.55	-.13	-.52	-.38	-.33	-.30	-.28	.30	-.05	-.09	.04	-.07	.11
TA2	.28	.34	.26	.37	.29	.27	.41	.31	.34	.43	.44	.28	.34	.43
TA3	.10	-.10	.15	.04	.12	.07	.15	.04	.14	.21	.06	.09	.04	.22
TA4	-.50	-.42	-.34	-.44	-.66	-.65	-.32	-.47	.00	-.11	-.44	-.29	-.47	-.16
TA5	.09	.30	.03	.33	.19	.15	.64	.30	.40	.54	.35	.40	.24	.52
PS1	.62	.63	.38	.64	.67	.69	.72	.68	.44	.48	.53	.45	.48	.47
PS2	.34	.39	.21	.40	.39	.50	.59	.40	.47	.53	.43	.42	.34	.44
PS3	.40	.51	.28	.61	.54	.67	.80	.60	.39	.74	.70	.54	.54	.63
PS4	.36	.57	.37	.68	.47	.59	.77	.50	.43	.81	.68	.62	.48	.61
MOT	.58	.80	.43	.81	.84	.89	.86	.84	.46	1.10	1.04	.78	.88	.90
MEAN	5.25	4.60	6.01	4.77	5.05	5.29	4.93	5.23	5.50	5.59	5.72	5.44	5.78	5.67
SD	1.17	1.37	.91	1.44	1.16	1.16	1.31	1.14	1.25	1.14	1.13	1.10	1.05	1.12

	EG1	EG2	EG3	EG4	IG1	IG2	IG3	IG4	CL1	CL2	CL3	CL4	TA1	TA2
EG1	2.39													
EG2	.81	2.23												
EG3	.26	.26	.46											
EG4	.49	.71	.10	2.58										
IG1	.36	-.14	.18	.09	1.31									
IG2	.30	-.20	.29	.06	.79	1.48								
IG3	.41	.18	.26	.17	.34	.43	1.33							
IG4	.03	-.56	.02	-.09	.59	.77	.29	2.13						
CL1	.18	-.08	.18	-.04	.39	.28	.23	.22	.66					
CL2	.07	.04	.14	.09	.32	.34	.33	.46	.11	1.91				
CL3	.15	-.08	.24	-.03	.41	.52	.31	.37	.34	.25	.73			
CL4	-.05	.00	.11	.04	.29	.27	.23	.46	.19	.68	.34	1.40		
TA1	.18	.67	.05	.47	.06	-.19	.17	-.01	.06	.47	-.05	.28	3.06	
TA2	.40	.09	.16	.07	.39	.37	.47	.28	.15	.34	.18	.21	.17	1.48
TA3	.44	.44	.10	.48	-.06	-.04	.41	-.08	-.08	.24	.00	.00	.54	.37
TA4	.24	.40	-.21	.43	-.22	-.33	-.22	-.05	-.19	.15	-.29	.07	.96	.01
TA5	.75	.38	.02	.65	.22	.20	.32	.30	.00	.41	.11	.33	.53	.46
PS1	.47	.11	.23	.43	.52	.44	.38	.36	.22	.18	.31	.25	.05	.22
PS2	.68	.26	.17	.49	.29	.36	.42	.42	.07	.14	.15	.13	.24	.38
PS3	.55	-.04	.11	.72	.59	.50	.38	.82	.08	.30	.21	.12	.02	.32
PS4	.55	.30	.26	.55	.61	.55	.35	.67	.10	.25	.26	.12	.02	.38
MOT	.83	-.04	.15	.77	.94	.78	.40	.93	.15	.55	.35	.18	-.07	.44
MEAN	5.02	4.81	6.59	4.53	5.60	5.76	5.80	4.86	6.15	4.77	6.16	5.41	4.40	5.15
SD	1.54	1.49	.68	1.61	1.15	1.22	1.16	1.46	.81	1.38	.85	1.19	1.75	1.22

	TA3	TA4	TA5	PS1	PS2	PS3	PS4	MOT
TA3	2.68							
TA4	.45	2.44						
TA5	.45	.91	2.61					
PS1	.26	-.10	.34	1.87				
PS2	.42	.16	.72	1.01	2.58			
PS3	.38	.09	.51	1.26	1.75	3.71		
PS4	.39	-.04	.62	1.24	1.63	2.18	3.59	
MOT	.19	-.23	.52	1.37	1.44	2.72	2.45	4.70
MEAN	4.36	3.25	4.31	5.28	4.43	3.62	4.82	4.82
SD	1.64	1.56	1.61	1.37	1.61	1.93	1.90	2.17

APPENDIX D

VARIABLE COVARIANCES, MEANS, AND STANDARD DEVIATIONS (SCIENCE GROUP)

	GENDER	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	TV1	TV2	TV3	TV4	TV5	TV6
GENDER	.18														
SE1	-.03	1.25													
SE2	-.08	.79	1.69												
SE3	-.02	.30	.45	.75											
SE4	-.08	.75	1.39	.52	1.97										
SE5	-.01	.73	.66	.37	.80	1.18									
SE6	-.02	.75	.59	.34	.72	.80	1.07								
SE7	-.07	.44	.53	.28	.58	.55	.49	1.54							
SE8	-.04	.71	.70	.36	.82	.76	.74	.55	1.12						
TV1	-.04	.43	.43	.23	.37	.27	.31	.36	.41	1.49					
TV2	.02	.13	.25	.22	.27	.15	.26	.26	.26	.24	.97				
TV3	-.02	.33	.41	.27	.54	.38	.45	.35	.45	.24	.32	.83			
TV4	-.02	.37	.56	.27	.54	.43	.44	.29	.41	.44	.37	.48	1.01		
TV5	-.01	.30	.38	.27	.39	.39	.34	.35	.39	.17	.28	.43	.33	.72	
TV6	-.01	.31	.36	.20	.34	.30	.39	.42	.40	.20	.48	.34	.42	.37	.96
EG1	.01	.04	.29	.13	.22	.02	.03	.03	.11	.02	.39	.14	.11	.10	.34
EG2	.05	.01	.00	.07	.04	-.01	.01	-.18	-.03	-.06	.16	.02	.10	-.10	.03
EG3	.02	.14	.11	.23	.20	.16	.17	-.04	.15	.08	.18	.15	.14	.07	.06
EG4	-.03	-.01	.09	-.02	.01	-.04	.04	.24	.27	.12	.03	-.14	-.14	-.15	.06
IG1	-.06	.36	.43	.26	.35	.36	.38	.30	.39	.30	.19	.36	.29	.33	.26
IG2	-.06	.35	.61	.34	.66	.30	.37	.37	.41	.29	.28	.53	.42	.34	.30
IG3	.03	.29	.26	.20	.33	.28	.41	.26	.31	.34	.38	.28	.42	.21	.41
IG4	-.05	.03	.48	.18	.52	.27	.28	.30	.33	.24	.25	.46	.43	.50	.35
CL1	-.01	.30	.46	.29	.44	.29	.31	.09	.33	.27	.10	.19	.19	.15	.14
CL2	-.02	-.02	.40	.14	.32	.10	.10	.22	.24	.02	.39	.18	.33	.29	.33
CL3	-.02	.36	.46	.36	.55	.40	.43	.32	.43	.19	.22	.37	.35	.30	.27
CL4	.02	.17	.30	.14	.28	.27	.28	.23	.40	.09	.19	.17	.30	.44	.27
TA1	.00	-.35	-.42	-.08	-.47	-.25	-.16	-.19	-.17	.36	-.10	-.02	.18	.00	.13
TA2	.03	.25	.21	.23	.24	.23	.17	.26	.20	.20	.31	.35	.25	.27	.35
TA3	.00	.09	-.13	.03	-.12	.04	.08	.03	.08	.27	.12	-.03	.14	-.08	.15
TA4	-.07	-.53	-.26	-.24	-.29	-.62	-.52	-.14	-.35	.11	-.12	-.23	-.11	-.23	-.02
TA5	.02	-.01	.27	-.01	.18	.19	.08	.67	.24	.35	.36	.16	.36	.19	.47
PS1	-.01	.47	.42	.30	.40	.48	.40	.46	.45	.29	.06	.17	.22	.21	.19
PS2	.08	.25	.20	.13	.23	.22	.31	.35	.26	.35	.16	.14	.25	.13	.24
PS3	.04	.03	.08	.13	.27	.06	.16	.31	.17	.16	.14	.14	.17	.09	.18
PS4	-.06	.25	.29	.31	.42	.13	.22	.41	.22	.25	.14	.20	.20	.10	.08
MEAN	.23	5.42	4.85	6.13	5.04	5.33	5.56	5.21	5.47	5.65	5.94	6.02	5.69	6.04	5.94
SD	.42	1.12	1.30	.87	1.40	1.09	1.04	1.24	1.06	1.22	.98	.91	1.00	.85	.98

	EG1	EG2	EG3	EG4	IG1	IG2	IG3	IG4	CL1	CL2	CL3	CL4	TA1	TA2
EG1	2.17													
EG2	.80	2.19												
EG3	.17	.28	.40											
EG4	.23	.54	.02	2.12										
IG1	.01	-.22	.09	-.07	1.01									
IG2	.16	-.18	.18	.00	.53	1.08								
IG3	.24	.22	.22	.11	.21	.23	1.16							
IG4	-.24	-.50	-.04	-.23	.44	.62	.14	2.09						
CL1	.05	-.10	.13	-.10	.32	.24	.22	.23	.62					
CL2	-.07	-.04	.08	-.03	.19	.18	.22	.47	.07	1.88				
CL3	.03	-.06	.17	-.04	.28	.37	.24	.29	.29	.20	.60			
CL4	-.10	-.06	.09	-.04	.20	.17	.20	.57	.18	.68	.32	1.43		
TA1	.15	.59	.03	.36	.12	-.12	.14	.18	.06	.40	-.06	.41	3.52	
TA2	.36	.17	.20	-.09	.26	.21	.41	.19	.19	.26	.19	.27	.16	1.49
TA3	.38	.43	.07	.42	-.18	-.13	.30	-.18	-.09	.14	-.04	.10	.54	.27
TA4	.30	.12	-.17	.36	-.14	-.14	-.26	.19	-.24	.20	-.25	.18	.99	-.05
TA5	.59	.40	-.01	.59	-.01	-.03	.20	.22	-.08	.48	.12	.44	.62	.34
PS1	.15	.05	.19	.23	.32	.19	.35	.04	.19	.07	.20	.30	.19	.18
PS2	.48	.38	.21	.27	.00	.09	.47	.21	.07	.01	.11	.17	.42	.29
PS3	.05	.05	.10	.14	.11	.17	.31	.48	.02	-.02	.09	.03	.08	.08
PS4	-.03	.24	.21	.10	.25	.24	.27	.28	.14	.06	.21	.13	.14	.21
MEAN	5.32	4.85	6.63	4.85	5.87	6.00	5.92	5.14	6.19	4.97	6.27	5.50	4.39	5.31
SD	1.47	1.48	.63	1.46	1.01	1.04	1.08	1.45	.79	1.37	.77	1.19	1.88	1.22

	TA3	TA4	TA5	PS1	PS2	PS3	PS4
TA3	2.69						
TA4	.45	2.54					
TA5	.43	.94	2.87				
PS1	.22	-.10	.18	1.26			
PS2	.44	.28	.58	.62	2.39		
PS3	.29	.30	.18	.53	1.17	2.89	
PS4	.26	.09	.31	.48	.77	.99	2.07
MEAN	4.48	3.25	4.53	5.73	4.92	4.53	5.65
SD	1.64	1.59	1.70	1.12	1.55	1.70	1.44

APPNDIX E

VARIABLE COVARIANCES, MEANS, AND STANDARD DEVIATIONS

(NON-SCIENCE GROUP)

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	TV1	TV2	TV3	TV4	TV5	TV6
SE1	1.44													
SE2	1.08	1.97												
SE3	.55	.65	.92											
SE4	1.07	1.40	.72	1.95										
SE5	.72	.91	.58	1.00	1.28									
SE6	.98	1.08	.59	1.04	1.05	1.48								
SE7	.53	1.01	.46	.98	.74	.82	1.73							
SE8	.94	.98	.47	1.07	.84	1.02	.67	1.36						
TV1	.48	.54	.41	.50	.39	.55	.49	.47	1.59					
TV2	.49	.53	.30	.65	.43	.53	.53	.47	.43	1.35				
TV3	.72	.78	.64	1.08	.74	.81	.92	.82	.77	.84	1.60			
TV4	.41	.43	.39	.63	.44	.49	.54	.38	.59	.53	.83	1.30		
TV5	.70	.77	.66	.99	.67	.81	.77	.76	.56	.68	1.22	.59	1.44	
TV6	.45	.46	.47	.65	.44	.51	.63	.44	.34	.86	.94	.56	.87	1.41
EG1	.27	.63	.22	.40	.32	.34	.39	.19	.17	.57	.39	.36	.26	.46
EG2	-.14	-.01	.00	-.38	-.21	-.23	-.28	-.20	-.15	.00	-.45	-.12	-.35	-.01
EG3	.33	.40	.35	.44	.29	.38	.25	.27	.25	.28	.42	.34	.39	.35
EG4	.13	.03	.09	-.04	.01	.15	-.04	.33	-.03	-.02	-.13	-.11	-.10	.03
IG1	.45	.77	.44	.86	.52	.52	.83	.59	.63	.55	.97	.51	.79	.55
IG2	.68	.93	.48	1.19	.60	.63	.92	.76	.52	.66	1.20	.70	.98	.72
IG3	.30	.49	.39	.45	.44	.38	.34	.30	.38	.46	.54	.45	.44	.51
IG4	.20	.59	.17	.59	.41	.39	.83	.36	.33	.28	.51	.42	.59	.43
CL1	.34	.49	.30	.53	.28	.33	.28	.37	.24	.18	.37	.10	.38	.28
CL2	-.01	.14	.12	.08	-.02	-.13	.22	.07	.14	.55	.28	.05	.17	.38
CL3	.38	.56	.32	.64	.36	.35	.28	.50	.27	.31	.66	.33	.60	.39
CL4	.17	.32	.11	.32	.05	.13	.24	.26	.22	.26	.32	.07	.32	.34
TA1	-.54	-.72	-.22	-.56	-.59	-.61	-.45	-.44	.22	.03	-.20	-.18	-.16	.09
TA2	.22	.35	.24	.39	.20	.26	.47	.32	.46	.40	.41	.19	.29	.39
TA3	.03	-.17	.30	.15	.10	-.05	.22	-.14	-.13	.20	.08	-.08	.09	.21
TA4	-.47	-.67	-.50	-.67	-.74	-.86	-.61	-.68	-.18	-.10	-.76	-.57	-.85	-.37
TA5	.09	.12	-.01	.32	-.06	.02	.34	.16	.36	.55	.41	.26	.08	.37
PS1	.56	.50	.29	.54	.47	.66	.63	.61	.40	.51	.56	.37	.44	.42
PS2	.14	.19	.08	.18	.11	.26	.44	.14	.38	.43	.29	.22	.15	.23
PS3	.35	.29	.08	.23	.27	.47	.58	.38	.20	.43	.46	.22	.31	.32
PS4	-.03	.20	.06	.26	.09	.27	.42	.14	.22	.71	.41	.46	.20	.52
MEAN	4.98	4.22	5.82	4.38	4.62	4.86	4.50	4.85	5.27	5.05	5.24	5.06	5.37	5.24
SD	1.20	1.40	.96	1.40	1.13	1.22	1.32	1.17	1.26	1.16	1.27	1.14	1.20	1.19

	EG1	EG2	EG3	EG4	IG1	IG2	IG3	IG4	CL1	CL2	CL3	CL4	TA1	TA2
EG1	2.39													
EG2	.78	2.32												
EG3	.36	.24	.54											
EG4	.52	.92	.17	2.91										
IG1	.57	-.06	.27	.01	1.51									
IG2	.25	-.28	.44	-.16	.93	1.89								
IG3	.54	.10	.30	.10	.41	.65	1.57							
IG4	.11	-.71	.06	-.24	.53	.76	.39	1.90						
CL1	.35	-.05	.25	.01	.46	.31	.22	.17	.71					
CL2	.05	.13	.18	.02	.30	.41	.42	.22	.16	1.79				
CL3	.20	-.13	.35	-.15	.50	.65	.36	.37	.42	.25	.90			
CL4	-.07	.08	.14	.05	.32	.34	.23	.21	.20	.63	.35	1.36		
TA1	.22	.81	.08	.65	-.03	-.28	.21	-.29	.05	.58	-.04	.09	2.34	
TA2	.28	-.05	.09	.11	.42	.46	.51	.24	.06	.36	.09	.07	.23	1.35
TA3	.41	.45	.15	.45	.00	-.02	.55	-.05	-.08	.31	.01	-.20	.58	.44
TA4	.15	.86	-.28	.55	-.33	-.64	-.16	-.44	-.11	.09	-.36	-.10	.93	.09
TA5	.75	.31	.04	.46	.32	.35	.40	.18	.08	.12	.01	.07	.43	.51
PS1	.43	.11	.23	.16	.35	.41	.21	.36	.20	-.01	.30	.01	-.15	-.02
PS2	.41	-.03	.03	.20	.21	.31	.10	.22	-.01	-.07	.00	-.10	-.04	.21
PS3	.24	-.36	-.04	.45	.34	.14	.06	.35	.05	.06	.01	-.07	-.07	.12
PS4	.47	.23	.20	.15	.28	.23	.07	.37	-.07	-.14	-.02	-.20	-.20	.13
MEAN	4.55	4.73	6.52	4.01	5.17	5.38	5.61	4.43	6.10	4.45	5.99	5.27	4.40	4.91
SD	1.55	1.52	.74	1.71	1.23	1.38	1.25	1.38	.85	1.34	.95	1.17	1.53	1.16

	TA3	TA4	TA5	PS1	PS2	PS3	PS4
TA3	2.65						
TA4	.47	2.32					
TA5	.38	.88	2.01				
PS1	.13	-.10	.19	2.04			
PS2	.19	-.02	.52	.77	1.92		
PS3	.12	-.21	.23	.77	.86	1.66	
PS4	.26	-.23	.39	.94	1.34	.97	3.19
MEAN	4.19	3.26	3.97	4.58	3.66	2.18	3.50
SD	1.63	1.52	1.42	1.43	1.39	1.29	1.79

APPENDIX F

VARIABLE COVARIANCES, MEANS, AND STANDARD DEVIATIONS (MALE GROUP)

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	TV1	TV2	TV3	TV4	TV5	TV6
SE1	1.37													
SE2	.85	1.72												
SE3	.35	.51	.81											
SE4	.82	1.31	.53	1.92										
SE5	.81	.78	.43	.89	1.31									
SE6	.82	.70	.38	.80	.91	1.20								
SE7	.44	.53	.26	.51	.61	.57	1.47							
SE8	.75	.72	.34	.86	.75	.78	.49	1.13						
TV1	.54	.59	.28	.54	.41	.48	.44	.53	1.50					
TV2	.17	.33	.19	.32	.25	.31	.32	.33	.37	1.14				
TV3	.40	.48	.32	.61	.48	.56	.45	.53		.47	1.03			
TV4	.50	.64	.32	.64	.56	.60	.34	.51	.62	.49	.66	1.23		
TV5	.37	.45	.35	.50	.48	.43	.42	.45	.30	.43	.56	.46	.85	
TV6	.31	.38	.20	.32	.35	.41	.50	.37	.34	.61	.47	.54	.47	1.10
EG1	-.01	.29	.15	.15	.18	.12	.14	.16	.22	.53	.33	.29	.21	.46
EG2	.05	.02	.08	-.10	-.11	-.10	-.24	-.05	-.02	.18	.00	.10	-.11	.09
EG3	.18	.17	.26	.26	.20	.21	.00	.18	.20	.16	.21	.22	.13	.09
EG4	.06	.26	.07	.14	.11	.17	.34	.40	.16	.17	.08	-.02	.02	.14
IG1	.42	.49	.29	.43	.40	.43	.36	.45	.53	.28	.54	.44	.44	.30
IG2	.42	.64	.36	.76	.37	.38	.41	.48	.44	.34	.70	.48	.49	.29
IG3	.34	.38	.24	.42	.40	.49	.29	.37	.48	.53	.42	.54	.29	.49
IG4	.10	.54	.16	.54	.42	.36	.42	.38	.40	.28	.47	.39	.52	.41
CL1	.34	.49	.30	.52	.31	.32	.08	.34	.40	.13	.20	.23	.17	.17
CL2	.00	.49	.23	.32	.11	.06	.24	.23	.11	.58	.25	.37	.32	.41
CL3	.45	.55	.35	.60	.42	.46	.33	.49	.33	.28	.44	.39	.37	.31
CL4	.18	.36	.14	.26	.25	.24	.20	.39	.18	.20	.19	.27	.42	.28
TA1	-.28	-.22	.03	-.15	-.13	-.08	.04	.03	.35	.12	.14	.22	.15	.37
TA2	.23	.21	.22	.20	.27	.19	.16	.22	.32	.34	.35	.24	.28	.36
TA3	.11	-.11	.14	-.13	.09	.06	.07	.10	.14	.24	.04	.06	.06	.29
TA4	-.51	-.32	-.26	-.36	-.64	-.59	-.22	-.31	-.06	-.04	-.29	-.35	-.25	.01
TA5	-.03	.29	-.08	.25	.20	.12	.55	.28	.29	.55	.24	.37	.24	.50
PS1	.56	.55	.30	.47	.60	.56	.57	.57	.46	.19	.42	.42	.41	.40
PS2	.19	.26	.11	.16	.32	.36	.42	.34	.45	.25	.30	.29	.26	.33
PS3	.06	.26	.09	.27	.30	.34	.57	.34	.33	.33	.50	.40	.36	.46
PS4	.23	.30	.21	.23	.33	.37	.38	.28	.38	.42	.49	.43	.28	.37
MOT	.19	.47	.21	.41	.47	.47	.32	.48	.36	.58	.64	.51	.50	.60
MEAN	5.40	4.82	6.12	5.04	5.22	5.47	5.20	5.42	5.60	5.77	5.89	5.58	5.94	5.81
SD	1.17	1.31	.90	1.39	1.14	1.09	1.21	1.06	1.23	1.07	1.01	1.11	.92	1.05

	EG1	EG2	EG3	EG4	IG1	IG2	IG3	IG4	CL1	CL2	CL3	CL4	TA1	TA2
EG1	2.31													
EG2	.76	2.33												
EG3	.24	.29	.45											
EG4	.50	.55	.02	2.35										
IG1	.30	-.08	.16	.10	1.13									
IG2	.21	-.10	.26	.04	.61	1.19								
IG3	.41	.27	.23	.34	.31	.35	1.42							
IG4	.01	-.59	-.04	.03	.51	.59	.24	2.05						
CL1	.21	-.04	.19	-.01	.39	.27	.27	.24	.69					
CL2	.12	.07	.11	.18	.27	.33	.43	.48	.14	2.05				
CL3	.14	-.07	.22	.11	.37	.48	.30	.33	.32	.30	.72			
CL4	.02	.01	.08	.09	.25	.25	.26	.43	.22	.76	.35	1.54		
TA1	.46	.71	.12	.51	.37	.03	.43	.18	.30	.70	.15	.47	3.45	
TA2	.44	.26	.21	.03	.29	.21	.54	.17	.13	.43	.22	.28	.39	1.53
TA3	.31	.36	.07	.52	-.08	-.12	.47	-.08	-.05	.44	.10	.13	.64	.42
TA4	.32	.38	-.19	.51	-.11	-.19	-.12	.08	-.13	.32	-.17	.28	.98	.02
TA5	.80	.53	-.03	.77	.15	.11	.37	.28	-.04	.55	.13	.45	.74	.32
PS1	.36	.04	.23	.43	.53	.41	.45	.29	.29	.00	.34	.20	.30	.18
PS2	.53	.25	.16	.57	.19	.25	.53	.50	.13	.04	.23	.09	.51	.30
PS3	.37	-.32	.04	.70	.30	.29	.48	.82	.10	.12	.22	-.12	.22	.09
PS4	.27	.16	.23	.43	.39	.33	.43	.49	.14	.09	.29	-.14	.19	.26
MOT	.48	-.19	.08	.72	.50	.36	.51	.71	.17	.32	.34	.03	.35	.26
MEAN	5.17	4.81	6.58	4.67	5.84	5.98	5.74	5.04	6.16	4.88	6.19	5.45	4.29	5.20
SD	1.52	1.53	.67	1.53	1.07	1.09	1.19	1.43	.83	1.43	.85	1.24	1.86	1.24

	TA3	TA4	TA5	PS1	PS2	PS3	PS4	MOT
TA3	2.76							
TA4	.54	2.64						
TA5	.42	1.05	2.85					
PS1	.25	-.09	.30	1.67				
PS2	.43	.34	.73	.79	2.50			
PS3	.37	.29	.42	.91	1.43	3.31		
PS4	.19	-.04	.40	.86	1.14	1.46	2.81	
MOT	.19	-.01	.33	.86	.74	1.69	1.57	3.19
MEAN	4.39	3.28	4.40	5.53	4.62	4.01	5.32	5.53
SD	1.66	1.63	1.69	1.29	1.58	1.82	1.68	1.79

APPENDIX G

VARIABLE COVARIANCES, MEANS, AND STANDARD DEVIATIONS (FEMALE GROUP)

	SE1	SE2	SE3	SE4	SE5	SE6	SE7	SE8	TV1	TV2	TV3	TV4	TV5	TV6
SE1	1.27													
SE2	.99	1.94												
SE3	.48	.57	.82											
SE4	.95	1.50	.72	1.99										
SE5	.66	.81	.53	.96	1.26									
SE6	.93	1.00	.59	1.00	1.06	1.46								
SE7	.52	1.00	.52	1.06	.76	.78	1.83							
SE8	.89	.98	.53	1.02	.97	1.07	.80	1.43						
TV1	.41	.40	.36	.34	.33	.42	.49	.39	1.54					
TV2	.59	.62	.44	.77	.57	.73	.65	.60	.33	1.44				
TV3	.74	.86	.62	1.14	.84	.88	.95	.88	.48	.91	1.53			
TV4	.27	.39	.35	.56	.40	.41	.58	.32	.40	.59	.75	1.11		
TV5	.71	.80	.58	.95	.72	.88	.80	.80	.43	.70	1.22	.56	1.41	
TV6	.57	.56	.53	.82	.57	.68	.67	.65	.23	.95	.97	.56	.91	1.41
EG1	.47	.81	.27	.67	.30	.42	.40	.27	-.04	.68	.34	.29	.30	.52
EG2	-.21	-.04	-.04	-.15	-.04	-.02	-.16	-.17	-.18	.04	-.39	-.11	-.32	-.09
EG3	.29	.34	.29	.38	.26	.37	.24	.26	.08	.37	.37	.24	.32	.34
EG4	.15	-.07	.01	-.08	.02	.20	.00	.31	.03	.10	-.19	-.08	-.14	.16
IG1	.41	.76	.42	.79	.62	.58	.81	.59	.29	.60	.83	.39	.75	.66
IG2	.60	.94	.47	1.05	.62	.72	.89	.72	.37	.78	1.11	.72	.89	.91
IG3	.34	.46	.44	.48	.42	.42	.48	.35	.29	.45	.54	.43	.50	.57
IG4	.13	.58	.24	.61	.33	.40	.73	.39	.23	.52	.73	.65	.77	.55
CL1	.29	.47	.30	.43	.27	.34	.33	.36	.05	.19	.38	.06	.37	.27
CL2	.04	.10	.03	.19	.11	.09	.30	.21	.05	.45	.33	.12	.27	.42
CL3	.28	.49	.35	.62	.41	.40	.36	.45	.11	.35	.66	.32	.57	.41
CL4	.18	.26	.13	.39	.14	.26	.35	.32	.12	.35	.38	.19	.41	.40
TA1	-.55	-.93	-.40	-.94	-.70	-.64	-.65	-.68	.19	-.29	-.45	-.22	-.40	-.28
TA2	.36	.53	.35	.62	.34	.40	.80	.47	.31	.53	.58	.36	.43	.57
TA3	.04	-.16	.13	.21	.09	.05	.22	-.13	.15	.15	.07	.11	-.05	.07
TA4	-.50	-.57	-.50	-.57	-.71	-.75	-.48	-.76	.03	-.29	-.74	-.20	-.88	-.44
TA5	.24	.25	.17	.37	.12	.15	.71	.26	.52	.47	.47	.41	.17	.51
PS1	.55	.49	.40	.60	.58	.71	.65	.63	.36	.78	.57	.34	.46	.43
PS2	.48	.45	.30	.64	.42	.61	.70	.38	.43	.84	.51	.56	.35	.55
PS3	.72	.57	.39	.75	.66	.93	.76	.71	.32	1.12	.73	.52	.58	.66
PS4	.27	.57	.40	.90	.38	.59	.86	.47	.32	1.07	.62	.64	.48	.71
MOT	.75	.70	.42	.72	.96	1.07	.95	.86	.33	1.41	1.15	.76	1.05	.96
GROUP	-.11	-.11	-.07	-.12	-.19	-.18	-.16	-.15	-.04	-.27	-.18	-.14	-.16	-.18
MEAN	4.99	4.23	5.84	4.35	4.79	4.99	4.48	4.91	5.39	5.31	5.45	5.22	5.55	5.45
SD	1.13	1.39	.91	1.41	1.12	1.21	1.35	1.19	1.24	1.20	1.24	1.05	1.19	1.19

	EG1	EG2	EG3	EG4	IG1	IG2	IG3	IG4	CL1	CL2	CL3	CL4	TA1	TA2
EG1	2.48													
EG2	.88	2.07												
EG3	.29	.19	.45											
EG4	.38	.93	.21	2.90										
IG1	.30	-.25	.21	-.07	1.37									
IG2	.33	-.38	.37	-.02	.89	1.79								
IG3	.45	.06	.31	-.06	.46	.63	1.20							
IG4	-.07	-.56	.09	-.41	.58	.92	.40	2.13						
CL1	.12	-.17	.14	-.11	.38	.31	.16	.15	.61					
CL2	-.09	-.01	.18	-.12	.28	.28	.22	.37	.08	1.65				
CL3	.13	-.15	.26	-.31	.43	.57	.34	.38	.35	.17	.73			
CL4	-.19	-.03	.16	-.06	.31	.27	.19	.49	.15	.57	.33	1.21		
TA1	-.23	.58	-.10	.43	-.38	-.40	-.24	-.20	-.34	.12	-.40	.00	2.27	
TA2	.34	-.11	.13	.15	.52	.58	.40	.48	.20	.21	.16	.11	-.12	1.33
TA3	.63	.54	.13	.37	-.07	.06	.35	-.15	-.16	-.11	-.22	-.23	.42	.32
TA4	.10	.48	-.25	.31	-.45	-.58	-.37	-.26	-.28	-.14	-.50	-.27	.94	-.06
TA5	.63	.14	.09	.41	.21	.29	.28	.29	.05	.14	.07	.12	.23	.67
PS1	.49	.20	.24	.30	.29	.26	.30	.26	.09	.39	.22	.28	-.17	.25
PS2	.84	.29	.20	.28	.27	.38	.29	.20	-.03	.20	.03	.19	-.11	.45
PS3	.60	.36	.19	.51	.65	.52	.35	.55	.02	.42	.12	.43	-.19	.67
PS4	.71	.52	.32	.46	.48	.46	.34	.62	.03	.27	.15	.46	-.06	.50
MOT	.95	.15	.25	.41	.92	.82	.42	.79	.10	.58	.25	.33	-.51	.68
GROUP	-.21	-.10	-.05	-.16	-.15	-.12	-.06	-.13	.00	-.12	-.02	-.09	.09	-.13
MEAN	4.79	4.80	6.59	4.31	5.23	5.40	5.87	4.57	6.15	4.59	6.11	5.35	4.61	5.08
SD	1.58	1.44	.67	1.70	1.17	1.34	1.10	1.46	.78	1.28	.85	1.10	1.51	1.15

	TA3	TA4	TA5	PS1	PS2	PS3	PS4	MOT	GROUP
TA3	2.57								
TA4	.34	2.14							
TA5	.48	.68	2.22						
PS1	.23	-.13	.33	1.95					
PS2	.44	-.17	.66	1.23	2.60				
PS3	.34	-.28	.52	1.46	2.02	3.79			
PS4	.69	-.11	.83	1.35	2.07	2.58	3.89		
MOT	.11	-.66	.60	1.48	2.04	3.24	2.38	5.03	
GROUP	-.06	.10	-.15	-.31	-.42	-.63	-.51	-.96	.24
MEAN	4.33	3.22	4.19	4.87	4.13	3.00	4.01	3.66	.63
SD	1.60	1.46	1.49	1.40	1.61	1.95	1.97	2.24	.49

APPENDIX H

SIMPLIS SYNTAX (CFA FOR THE WHOLE SAMPLE)

```
observed variables
se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matirix from file: diss.cov
sample size 359
latent variables: se tv eg ig cl ta ps
relationships:
se1-se8 = se
tv1-tv6 = tv
eg1-eg4 = eg
ig1-ig4 = ig
cl1-cl4 = cl
ta1-ta5 = ta
ps1-ps4 = ps
set the error covariance between tv2 and tv6 free
set the error covariance between se2 and se4 free
set the error covariance between cl2 and cl4 free
options nd=3 sc mi rs
```

APPENDIX I

SIMPLIS SYNTAXES (FACTOR MEAN DIFFERENCES BETWEEN THE SCIENCE GROUP AND THE NON-SCIENCE GROUP)

Appendix I1. One-Group CFA

One-group CFA for the science group.

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_asp.cov
sample size: 220
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se
se2-se8 = se
tv6 = 1*tv
tv1-tv5 = tv
eg4 = 1*eg
eg1-eg3 = eg
ig1 = 1*ig
ig2-ig4 = ig
cl1 = 1*cl
cl2-cl4 = cl
ta3 = 1*ta
ta1 ta2 ta4 ta5 =ta
ps1 = 1*ps
ps2-ps4 = ps
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3
```

One-group CFA for the non-science group.

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_nonasp.cov
sample size: 139
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se
se2-se8 = se
tv6 = 1*tv
tv1-tv5 = tv
eg4 = 1*eg
eg1-eg3 = eg
ig1 = 1*ig
ig2-ig4 = ig
cl1 = 1*cl
```

```
cl2-cl4 = cl
ta3 = 1*ta
ta1 ta2 ta4 ta5 =ta
ps1 = 1*ps
ps2-ps4 = ps
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3
```

Appendix I2. Configural Invariance

```
title test of configural invariance across science and nonscience group
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_asp.cov
means from file diss_asp.me
sample size: 220
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3

group2 nonasp
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_nonasp.cov
means from file diss_nonasp.me
sample size: 139
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 =eg + const
ig1 = 1*ig + const
ig2-ig4 =ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
```

```
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
set the path from const to se1-ps4 free
options mi sc nd=3
```

Appendix I3. Metric Invariance

```
title test of metric invariance across science and nonscience group
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_asp.cov
means from file diss_asp.me
sample size: 220
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi nd=3

group2 nonsci
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_nonasp.cov
means from file diss_nonasp.me
sample size: 139
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = const
tv6 = 1*tv + const
tv4 = tv + const
tv1 - tv3 tv5 = const
eg4 = 1*eg + const
eg1 eg2 eg3 = const
ig1 = 1*ig + const
ig2-ig4 = const
```

```
cl1 =1*cl + const
cl2-cl4 = const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5  = const
ps1 = 1*ps + const
ps2-ps4 = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
set the path from const to se1-ps4 free
options mi
```

Appendix I4. Scalar Invariance

```
title test of scalar invariance across science and nonscience
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_asp.cov
means from file diss_asp.me
sample size: 220
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi nd=3

group2 nonsci
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_nonasp.cov
means from file diss_nonasp.me
sample size: 139
latent variables: se tv eg ig cl ta ps
relationships:
tv4 = tv + const
ps3 ps4 tv2 ps1 = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variances of se1 - ps4 free
```

```
set the variance of se - ps free
set the covariance of se - ps free
options  mi nd =3
```

Appendix I5. Structured Means Model

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_asp.cov
means from file diss_asp.me
sample size: 220
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1-eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free

group2 nonscience
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_nonasp.cov
means from file diss_nonasp.me
sample size: 139
latent variables: se tv eg ig cl ta ps
relationships:
tv1 tv4 = tv + const
se = const
tv = const
eg = const
ig = const
cl = const
ta = const
ps = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
set the path from const to ps3 free
set the path from const to ps4 free
set the path from const to tv2 free
set the path from const to ps1 free
options: ND = 3 SC MI
```

APPENDIX J

SIMPLIS SYNTAXES (FACTOR MEAN DIFFERENCES BETWEEN THE MALE GROUP AND THE FEMALE GROUP)

Appendix J1. One-Group CFA

One-group CFA for the male group.

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se
se2-se8 = se
tv1 = 1*tv
tv2-tv6 = tv
eg2 = 1*eg
eg1 eg3 eg4 = eg
ig1 = 1*ig
ig2-ig4 = ig
cl1 = 1*cl
cl2-cl4 = cl
ta1 = 1*ta
ta2-ta5 =ta
ps1 = 1*ps
ps2-ps4 = ps
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3
```

One-group CFA for the female group.

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se
se2-se8 = se
tv1 = 1*tv
tv2-tv6 = tv
eg2 = 1*eg
eg1 eg3 eg4 = eg
ig1 = 1*ig
ig2-ig4 = ig
cl1 = 1*cl
```

```
cl2-cl4 = cl
ta1 = 1*ta
ta2-ta5 =ta
ps1 = 1*ps
ps2-ps4 = ps
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3
```

Appendix J2. Configural Invariance

```
title test of configural invariance by gender
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
means from file diss_m.me
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv1 = 1*tv + const
tv2-tv6 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta1 = 1*ta + const
ta2-ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi sc nd=3

group2 female
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
means from file diss_f.me
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv1 = 1*tv + const
tv2-tv6 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 =eg + const
ig1 = 1*ig + const
ig2-ig4 =ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
```

```
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
set the path from const to se1-ps4 free
options mi sc nd=3
```

Appendix J3. Metric Invariance

```
title test of metric invariance by gender
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
means from file diss_m.me
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options  mi nd=3

group2 female
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
means from file diss_f.me
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = const
tv6 = 1*tv + const
tv1 tv4  = tv + const
tv2 tv3 tv5 = const
eg4 = 1*eg + const
eg1 eg2 eg3 = const
ig1 = 1*ig + const
ig2-ig4 = const
```

```
cl1 =1*cl + const
cl2-cl4 = const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5  = const
ps1 = 1*ps + const
ps2-ps4 = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
options mi
```

Appendix J4. Scalar Invariance

```
title test of scalar invariance by gender
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
means from file diss_m.me
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options   sc nd=3

group2 female
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
means from file diss_f.me
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
tv1 tv4 = tv + const
ps4 ig3 se7 = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1 - ps4 free
set the variance of se - ps free
```

```
set the covariance of se - ps free
options  sc
```

Appendix J5. Measurement Error Invariance

```
title test of measurement error invariance by gender
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
means from file diss_m.me
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1 eg2 eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
options   sc nd=3

group2 female
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
means from file diss_f.me
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
tv1 tv4 = tv + const
ps4 ig3 se7 = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the variance of se - ps free
set the covariance of se - ps free
options  sc
```

Appendix J6. Structured Means Model

```
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_m.cov
means from file diss_m.me
sample size: 221
latent variables: se tv eg ig cl ta ps
relationships:
se1 = 1*se + const
```

```
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
eg4 = 1*eg + const
eg1-eg3 = eg + const
ig1 = 1*ig + const
ig2-ig4 = ig + const
cl1 =1*cl + const
cl2-cl4 = cl + const
ta3 = 1*ta + const
ta1 ta2 ta4 ta5 = ta + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free

group2 female
observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
covariance matrix from file diss_f.cov
means from file diss_f.me
sample size: 135
latent variables: se tv eg ig cl ta ps
relationships:
tv1 tv4 = tv + const
se = const
tv = const
eg = const
ig = const
cl = const
ta = const
ps = const
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error covariance of cl2 and cl4 free
set the error variance of se1-ps4 free
set the variance of se - ps free
set the covariance of se - ps free
set the path from const to ps4 free
set the path from const to ig3 free
set the path from const to se7 free
options: ND = 3 SC MI
```

APPENDIX K

SIMPLIS SYNTAX (MIMC MODEL FOR FACTOR MEAN DIFFERENCES BETWEEN THE MALE SCIENCE GROUP AND THE FEMALE SCIENCE GROUP)

```
 observed variables: gender se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5
ps1-ps4
 covariance matrix from file mimic_sci.cov
 sample size: 219
 latent variables: se tv eg ig cl ta ps
 relationships:
 se1 = 1*se
 se2-se8 = se
 tv6 = 1*tv
 tv1-tv5 = tv
 eg4 = 1*eg
 eg1 eg2 eg3 = eg
 ig1 = 1*ig
 ig2-ig4 = ig
 cl1 =1*cl
 cl2-cl4 = cl
 ta3 = 1*ta
 ta1 ta2 ta4 ta5 = ta
 ps1 = 1*ps
 ps2-ps4 = ps
 se tv eg ig cl ta ps = gender
 set the error covariance of se2 and se4 free
 set the error covariance of tv2 and tv6 free
 set the error covariance of cl2 and cl4 free
 set the covariance of se - ps free
 options  sc nd = 3
```

APPENDIX L

SIMPLIS SYNTAX (MIMIC MODEL FOR FACTOR MEAN DIFFERENCES BETWEEN THE FEMALE SCIENCE GROUP AND THE FEMALE NON-SCIENCE GROUP)

```
 observed variables: se1-se8 tv1-tv6 eg1-eg4 ig1-ig4 cl1-cl4 ta1-ta5 ps1-ps4
group
 covariance matrix from file diss_f_mimic.cov
 sample size: 135
 latent variables: se tv eg ig cl ta ps
 relationships:
 se1 = 1*se
 se2-se8 = se
 tv6 = 1*tv
 tv1-tv5 = tv
 eg4 = 1*eg
 eg1 eg2 eg3 = eg
 ig1 = 1*ig
 ig2-ig4 = ig
 cl1 =1*cl
 cl2-cl4 = cl
 ta3 = 1*ta
 ta1 ta2 ta4 ta5 = ta
 ps1 = 1*ps
 ps2-ps4 = ps
 se tv eg ig cl ta ps = group
 set the error covariance of se2 and se4 free
 set the error covariance of tv2 and tv6 free
 set the error covariance of cl2 and cl4 free
 set the covariance of se - ps free
 options  sc nd = 3
```

APPENDIX M

SIMPLIS SYNTAXES (STRUCTURAL REGRESSION MODEL)

Appendix M1. Whole Sample

```
title Full Model for whole sample
Observed variables: se1-se8 tv1-tv6 ps1-ps4 mot
covariance matrix from file: full_whole.cov
sample size 359
latent variables: se tv ps asp
relationships:
se1 = 1* se
se2-se8 = se
tv6 = 1* tv
tv1-tv5 = tv
ps1 = 1*ps
ps2-ps4 = ps
mot = asp
asp = se tv ps
tv = se ps
set the error of se2 and se4 covary
set the error of tv2 and tv6 covary
set the error variance of mot to 0.471
set the loading of mot on asp to 1.0
let se and ps covary
options: ss sc ef
end of program
```

Appendix M2. Multiple Group Structural Regression Model

```
title multiple group full model
observed variables: se1-se8 tv1-tv6 ps1-ps4 mot
covariance matrix from file: full_m.cov
means from file: full_m.me
latent variables: se tv ps asp
sample size: 221
relationships:
se1 = 1*se + const
se2-se8 = se + const
tv6 = 1*tv + const
tv1-tv5 = tv + const
ps1 = 1*ps + const
ps2-ps4 = ps + const
mot = 1* asp + const
tv = ps se
asp = tv ps se
set the error covariance of se2 and se4 free
set the error covariance of tv2 and tv6 free
set the error variance of mot to .47
options sc nd=3 ef
```

```
group2 female
Observed variables: se1-se8 tv1-tv6 ps1-ps4 mot
covariance matrix from file: full_f.cov
means from file: full_f.me
sample size 135
latent variables: se tv ps asp
relationships:
tv1 tv4 = tv + const
mot = 1* asp + const
ps4 se7 = const
asp = se tv ps
tv = se ps
set the error of se2 and se4 covary
set the error of tv2 and tv6 covary
set the error variance of mot to 0.471
options: ss sc ef
```

APPENDIX N

EXTRA-CURRICULAR SCIENCE ACTIVITIES

Appendix N1. Science Group Versus Non-Science Group

Science Students (N=235)		Non-Science Students (N=157)	
Response	Frequency	Response	Frequency
Private Academic Program(s)	164 (69.8)	Private Academic Program(s)	46(29.3)
School Science Club	32 (13.6)	School Science Club	13(8.3)
Participation in Gifted Program(s)	20 (8.5)	Participation in Gifted Program(s)	15(9.6)
Individual Research	20 (8.5)	Individual Research	9(5.7)
Camp or Science Exhibition	4 (1.7)	Camp or Science Exhibition	4(2.5)
Private Tutoring/ Internet Lecture	3 (1.3)	Private Tutoring/ Internet Lecture	14(8.9)
Attending Various Science Competitions (Not including Science Olympiads)	1 (0.4)	Attending Various Science Competitions (Not including Science Olympiads)	7(4.5)
Mentoring Program	1 (0.4)	Reading Scientific Books or Magazines	2(1.3)
No Specific Activities	11(4.7)	No Specific Activities	34(21.7)
Total Responses	256	Total Responses	144

Note. The percentage of each category presented in the parentheses was calculated based on each group's sample size N.

Appendix N2. Male Science Group Versus Female Science Group

Male Science Students (N=180)		Female Science Students (N=55)	
Response	Frequency	Response	Frequency
Private Academic Program(s)	120 (66.7)	Private Academic Program(s)	37 (67.3)
School Science Club	23 (12.8)	School Science Club	9 (16.4)
Individual Research	14 (7.8)	Individual Research	6 (10.9)
Participation in Gifted Program(s)	13 (7.2)	Participation in Gifted Program(s)	4 (7.3)
Private Tutoring/ Internet Lecture	1 (0.6)	Private Tutoring/ Internet Lecture	3(5.5)
Camp or Science Exhibition	3 (1.7)	Camp or Science Exhibition	2 (3.6)
Attending Various Science Competitions (Not including Science Olympiads)	0	Attending Various Science Competitions (Not including Science Olympiads)	1 (1.8)
Mentoring Program	0	Mentoring Program	1 (1.8)
No Specific Activities	5 (2.8)	No Specific Activities	4 (7.3)
Total Responses	179	Total Responses	67

Note. The percentage of each category presented in the parentheses was calculated based on each group's sample size N.

Appendix N3. Female Science Group Versus Female Non-Science Group

Female Science Students (N=55)		Female Non-Science Students (N=96)	
Response	Frequency	Response	Frequency
Private Academic Program(s)	37 (67.3)	Private Academic Program(s)	19 (19.8)
School Science Club	9 (16.4)	School Science Club	10 (10.4)
Individual Research	6 (10.9)	Individual Research	8 (8.3)
Participation in Gifted Program(s)	4 (7.3)	Participation in Gifted Program(s)	8 (8.3)
Private Tutoring/ Internet Lecture	3 (5.5)	Private Tutoring/ Internet Lecture	8 (8.3)
Camp or Science Exhibition	2 (3.6)	Camp or Science Exhibition	3 (3.1)
Attending Various Science Competitions (Not including Science Olympiads)	1 (1.8)	Attending Various Science Competitions (Not including Science Olympiads)	6 (6.3)
Mentoring Program	1 (1.8)	Reading Scientific Books or Magazines	1 (1.0)
No Specific Activities	4 (7.3)	No Specific Activities	25 (26.0)
Total Responses	67	Total Responses	88

Note. The percentage of each category presented in the parentheses was calculated based on each group's sample size N.

APPENDIX O

SELF-CONCEPT OF STUDENTS' OWN STRENGTHS FOR SCIENCE

Strengths	Science Group (N= 236)	Non-Science Group (N=158)	Male Group (N=242)	Female Group (N=152)	Male Science Group (N= 180)	Female Science Group (N=55)	Female Non-Science (N=96)
Persistent personality or attitude	86 (36.4)	49 (31.0)	82 (33.9)	54 (35.5)	64 (35.6))	21 (38.2)	31 (32.3)
Intrinsic interest or Inquiring attitude	75 (31.8)	72 (45.6)	72 (29.8)	74 (48.7)	53 (29.4)	22 (40.0)	52 (54.2)
Ability	33 (14.0)	4 (2.5)	29 (12.0)	8 (5.3)	29 (16.1)	4 (7.3)	4 (4.2)
Challenge seeking	10 (4.2)	4 (2.5)	11 (4.5)	3 (2.0)	8 (4.4)	2 (3.6)	1 (1.0)
Passion	7 (3.0)	4 (2.5)	8 (3.3)	3 (2.0)	6 (3.3))	1 (1.8)	2 (2.1)
Creativeness	7 (3.0)	4 (2.5)	7 (2.9)	4 (2.6)	4 (2.2)	3 (5.5)	1 (1.0)
Others	17 (7.2)	13 (8.2)	14 (5.8)	16 (10.5)	11 (6.1)	6 (10.9)	10 (10.4)
No Specific Response	52 (22.0)	35 (22.2)	60 (24.8)	28 (18.4)	40 (22.2)	12 (21.8)	16 (16.7)
Total Responses	235	150	223	162	175	59	101

Note. The percentage of each category presented in the parentheses was calculated based on each group's sample size N.