Factors that Influence Participation of Students in Secondary Science and Mathematics Subjects in IB Schools Outside of the United States and Canada

A DISSERTATION SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL OF THE UNIVERSITY OF MINNESOTA

BY

Elizabeth Straffon

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF EDUCATION

Deanne Magnusson, Ph.D., Adviser

Gerald Fry, Ph.D., Adviser

December 2011

ACKNOWLEDGEMENTS

I have had several “supports” and few “barriers” on my journey to meet my life goal of writing this dissertation. Thanking the countless people who lent an ear or gave a word of encouragement would be difficult to do individually, so thank you all collectively. Thank you colleagues and students past and present, peers in my UMN cohort and family both immediate and extended. Through this dissertation I have been able to bring several areas of interest for me together: science teaching, counseling, technology, and international schools.

There are some individuals who I want to mention by name. First, Michael Dean and the IBO, thanks for supporting my efforts by organizing the data sharing agreement and supplying the data-set in a professional, and timely manner. That the IBO is encouraging research is an important contribution to education.

I would also like to thank Brandon LeBeau, with the university’s Office of Research Consultation and Services (ORCS) group, for his patience and help last summer with the statistics, and support with follow-up emails. Discussions with Chu-Ting Chung and Dr. Everson were also invaluable to me and this study. Any limitations with the statistics here are my own.

To my principal advisers, Dr. Deanne Magnusson and Dr. Gerald Fry, thank you both for your constant and positive support for all your students, especially my very special cohort, even from a distance. You have supported my persistence to carry on when it was difficult. Dr. Tamara Moore and Dr. Francis Vavrus, thanks for taking some of your valuable time to participate on my committee and, in particular, Dr. Moore for allowing me to browse through your library.

To my colleagues in the technology department and to Kevin, Claudia, and Holly, for the statistical, technical and editing support, without it what would I have done? Thanks for your patience, good questions and attention to detail. Cheryl, Karen, Margaret and Connie, thanks for listening and allowing me to "practice on you" and for giving valuable feedback.

Lastly, to my family, Dave, Nate and Dan, I thank you so much for the gift of time. You never made me feel guilty about not being there enough with you over the past four years. I am back and we will make up for that lost time. Mom, I do wish that Dad could have been around to see me finish what he had encouraged all of his children to do. This study reinforces what I already know, that if a child is lucky enough to have supportive parents, the world can become an open door.

ABSTRACT

The purpose of this study was to investigate factors that affect the extent of international secondary students' participation in International Baccalaureate science and mathematics courses. The factors examined were gender, home region, size, percent host culture and age of the program, and coeducational and legal status of the school. Participation in math and science subjects was determined by analyzing the level and number of courses taken by students taking International Baccalaureate exams in 2010.

Chi-Square and Cramer's V analysis were used to measure the effect of categorical variables on student participation and One-Way ANOVA and Bonferroni comparison of means were used to analyze the quantitative variables. All categorical variables were statistically significant ($p<.01$). Home region was the most important factor affecting participation in both math and science. Students from East, Southeast and South-Central Asia; and Eastern Europe have greater participation in math. The highest science participation came from students in East, Southern and Western Africa; and Southeast Asia. Top participators in science came from Australia/New Zealand, Northern Europe, East Africa and South-Central and Western Asia. State schools showed higher math and science participation. Science and math participation was also greater in all-male schools though associations were weak. Boys participated more than girls, especially in math. All quantitative variables were statistically significant. The program size had the largest effect size for both math and science with larger programs showing more participation at the higher level. A decreasing trend for age of the program and percent host culture was found for math participation.

Three years of participation data were collected from an international school in Western Europe (n = 194). Variables included the influence of parent occupation, math preparedness (PSAT-Math), student achievement (GPA), and the importance of significant others in career and academic decisions. Findings indicate that performance on the PSAT- Math was the most important predictor of both science and mathematics participation. Twenty students were also interviewed. Results showed the importance of several key factors. These include the role of parents in student academic and career decisions, the importance of personal interest, and the contribution of early decisions in confidence-building.

TABLE OF CONTENTS

Acknowledgements	**i**
Abstract	**iii**
Table of Contents	**v**
List of Tables	**x**
List of Figures	**xi**
CHAPTER 1: INTRODUCTION	**1**
Statement of the Problem	1
Gaps in US Secondary Math and Science	3
Gaps in International Secondary School Math and Science	4
Gaps in Higher Education Science and Math Participation	5
Theoretical Framework	7
Overview of Factors Affecting Career Choice	9
Context	11
Statement of Study Purpose and Research Questions	14
Key Terms	14
Delimitations and Limitations	16
CHAPTER 2: LITERATURE REVIEW	**19**
Organization of the Literature Review	19
21st Century Skills and the Importance of STEM Subjects and Skills	19
Need for Participation of Women in STEM Workforce	22
Math as a Barrier	24
Gaps in US Science and Math Classrooms	26
Gender and Ethnic Participation Gaps in Secondary International School	27
Gaps in Participation in Science and Math in Higher Education	30
Gaps in Participation in UK Higher Education	31

Individual Factors 32

Psychological Considerations 32

Sociological Considerations 34

Cultural Considerations 35

Collective Efficacy and Culture 37

Biological Considerations 41

Environmental Factors 44

School Size 44

Gender Separate Schools 46

Significant Others 47

Social Cognitive Career Theory 48

SCCT and Current Research and Practice 52

Summary 55

CHAPTER 3: Study Design 59

Statement of Study Purpose and Research Questions 59

Rationale for Methodology 59

The IBO Data and Collection Methods 61

Data Set 1: IBO Data 62

Data Collection 62

Description of Math and Science Courses 63

Description of Standard and Higher Level Courses 64

Preparation of the IBO Data 64

Description of the Extent of Participation for Study 66

Analysis of the IBO Data 67

Data Set 2: AIS Statistical Data 68

Collection of AIS Data 68

Preparation of AIS Data 69
Analysis of AIS Data 69
Data Set 3: AIS Semi-Structured Interviews 70
Data Collection of Semi-Structured Interviews 70
Preparation and Analysis of Semi-structured Interviews 70
Summary of Methods 71
CHAPTER 4: RESULTS 74
International Baccalaureate World Data Analysis 74
Descriptive Statistics 74
Chi-Square Analysis of Categorical Variables 80
Gender and Math Participation 82
Gender and Science Participation 83
Individual and School Region and Math Participation 84
Individual and School Region and Science Participation 84
Legal Status and Math and Science Participation 88
Coeducational Status and Math and Science Participation 89
One-Way ANOVA for Analysis of Numerical Variables 91
Math Participation 91
Science Participation: 94
Science Participation – A Closer Look 96
Math as a Factor in Science Participation 97
Descriptive Comparison of Student Choice by Science Subject 98
American International School Data Analysis 100
Chi-Square for Categorical Variables 103
One-Way ANOVA for Numerical Variables 104
Gender and Numerical Variables 107

Science a Closer Look at AIS 108

Student Interviews 110

Summary of Results 114

Summary of IBO Data Set 1 114

Summary of AIS Data Set 2 117

Summary of Interview Data 117

CHAPTER 5: DISCUSSION 119

Policy Implications from IBO Data Set 119

Gender, Home Region and Policy Implications 120

Coeducational Status and Policy Implications 122

Legal Status and Policy Implications 124

Size of the Program and Policy Implications 125

Age of the Program and Policy Implications 126

Percent Host Culture and Policy Implications 127

Math as a Factor in Science Participation 127

Policy Implications from AIS Data Set 129

Interviews 133

Limitations of the Study 133

Conclusion 136

REFERENCES 138

APPENDICES 144

Appendix A IB Learner Profile 144

Appendix B IB Standards and Practices – Standard C1 146

Appendix C Semi-Structured Interview Questions 148

Appendix D Frequency Distributions of IBO Numerical Data 150

Appendix E Frequency and Participation by Individual Student Regions 151

Table 1 Frequency Distribution by Region 152

Table 2 Individual Student Region and Math Participation Cross Tabulation 152

Table 3 Individual Student Region and Science Participation Cross Tabulation 154

Appendix F Frequency and Distribution by School Region 157

Table 1 Frequency Distribution by School Region 157

Table 2 School Region and Math Participation Cross Tabulation 158

Table 3 School Region and Science Participation Cross Tabulation 160

Appendix G Cramer’s V Strength of Association 163

Appendix H Frequency Distribution of AIS Data 164

LIST OF TABLES

3.1	Description of the Extent of Participation in Mathematics - IBO and AIS	67
3.2	Description of the Extent of Participation in Science - IBO and AIS	67
3.3	Research Questions for Data Set 1 - IBO	72
3.4	Research Questions for Data Set 2 - AIS	73
4.1	Descriptive Statistics – Math and Science Participation - IBO	76
4.2	Descriptive Statistics for Numerical Variables - IBO	77
4.3	Descriptive Statistics for Categorical Variables for Math - IBO	78
4.4	Descriptive Statistics for Categorical Variables for Science - IBO	80
4.5	Chi-Square Statistics for Math Participation - IBO	80
4.6	Chi-Square Statistics for Science Participation - IBO	81
4.7	One-Way ANOVA for Math Participation vs. Numerical Variables - IBO	92
4.8	One-Way ANOVA for Science Participation vs. Numerical Variables	94
4.9	Chi Square for Science Subject Participation - IBO	97
4.10	Chi Square for Math Participation and Science Subject - IBO	98
4.11	Descriptive Statistics for Numerical Variables - AIS	101
4.12	Chi-Square for Categorical Variables -AIS	104
4:13	One-Way ANOVA for Math and Science Participation - AIS	105
4.14	Descriptive Statistics for Numerical Variables by Gender - AIS	108
4.15	Frequency of Students in Sciences by Gender - AIS	109
4.16	Counts of Students in Math by Gender / % of Total - AIS	110

LIST OF FIGURES

Figure 1	Social Cognitive Career Theory (Lent, 2005)	8
Figure 2	Participation in Science and Mathematics - IBO	75
Figure 3	Gender and Math Participation - IBO	83
Figure 4	Gender and Science Participation - IBO	84
Figure 5	Individual Region and Math Participation - IBO	85
Figure 6	School Region and Math Participation - IBO	86
Figure 7	Individual Region and Science Participation -IBO	87
Figure 8	School Region and Science Participation - IBO	88
Figure 9	Legal Status and Math and Science Participation - IBO	89
Figure 10	Coeducational Status and Math and Science Participation - IBO	91
Figure 11	Comparing Means of Numerical Variables in Math Participation	93
Figure 12	Comparing Means of Numerical Variables in Science Participation	95
Figure 13	Frequencies of Math and Science Participation - AIS	102
Figure 14	Comparing Means of Numerical Variables in Math Participation - AIS	106
Figure 15	Comparing Means of Numerical Variables in Math Participation - AIS	107

CHAPTER 1: INTRODUCTION

Statement of the Problem

The “STEM challenge” is a term used to describe the critical need for a global work force with a high level of proficiency in the areas of science, technology, engineering and mathematics (STEM subjects) as we move into the 21^{st} Century. Not only is there an expected critical shortage of these “knowledge” workers, but this problem is not that of the United States (US) alone. An understanding of factors affecting the participation of subjects in these courses may provide us with important solutions to serious challenges facing our planet. Solutions for these problems will require a joint effort by creative, committed scientists from all nations. Women and ethnic minorities are needed to help support the increased demands, but they need to be educated in these areas to keep pace economically in the workforce. For this reason, it is important to understand how secondary students enter these math and science subject areas and whether the trends seen in schools in the United States are also occurring internationally. To date, there has been little or no research on students graduating from International Baccalaureate (IB) schools in regard to this concern. Further, there is a gap in the research of data concerning how gender and ethnicity affect career choice (Lent, 2005).

Why is this an important challenge? The National Science Foundation (NSF) estimates that about five million people presently work directly in science, engineering, and technology. This represents about four percent of the workforce in the US (NSF, 2010). “This relatively small group of workers is considered to be critical to economic innovation and productivity” in the twenty-first century (US Department of Labor, 2003).

The US Department of Labor projects that by 2018, nine of the ten fastest growing occupations will require at least a bachelor's degree in science or math. In 2007, the US Department of Labor predicted that of the twenty fastest growing fields, seventeen will be in health care and computer field and there will be an overall growth in all science, technology, engineering and math related careers by the year 2014 (Department of Labor, 2007). It is important that the workforce grows and expands to support this need. According to a meta-analysis of research carried out by the American Association of University Women (AAUW), "Why So Few?",

> Scientists and engineers are working to solve some of the most vexing challenges of our time – finding cures for diseases like cancer and malaria, tackling global warming, providing people with clean drinking water, developing renewable energy sources, and understanding the origins of the universe...when women are not involved in the design of these products, needs and desires unique to women may be overlooked
>
> (AAUW, 2010, p. 3).

Women constitute about 46% of the workforce in the US but hold only about 26% of the STEM jobs, and only 10% of American engineers are women according to the National Math and Science Initiative (NMSI, 2008). According to the US labor statistics in 2000, only 27% of the jobs in computer and mathematics fields were held by females where nearly 75% of tomorrow's jobs will require the use of computers (NMSI, 2009).

STEM careers will make up the sixth largest employment sector by 2018, according to the Georgetown University, "Help Wanted: Projections of Jobs and Educational Requirements through 2018", and will rank at the top of all professions for the necessity of post-secondary qualifications (Carnevale, 2009). Compared with other Organization for Economic Cooperation and Development (OECD) countries, the US ranks twenty-seventh among twenty- nine in the rate of STEM degrees awarded (OECD, 2010). According to the NSF, China awarded forty-seven percent of its university degrees in the STEM fields; South Korea, thirty-eight percent; and Germany, twenty-eight percent. The US needs may be met in part by international students according to this NSF report. In 2007 over 33% of undergraduates and 50% of graduate students in STEM fields were international students (NSF, 2010). In *Waiting for Superman,* Weber asserts:

> The gap between what we need and what we are producing is large and growing. In fact, by 2020, 123 million American jobs will be high-skill/high-pay occupations, from computer programming to bioengineering, but only 50 million Americans will be qualified to fill them (Weber, 2010, p. 5).

Gaps in the US Secondary Science and Mathematics Participation. According to the American Association of Women Engineers (AAWE), the gaps in secondary participation in STEM subjects in the United States appear to be due to race and economics and not strongly due to gender if secondary academic success alone is considered, (AAWE, 2009). Girls tend to be earning math and science credits in high school at the same rate as boys. They are also earning higher grades on average in those classes, according to the National Center for Educational Statistics (NCES, 2010) report. But, higher performance by females in a STEM course at the secondary school level is not translating to higher achievement on critical exams such as the Advanced Placement (AP) or the Scholastic Aptitude Test (SAT II) subject exams, nor is it affecting the rates with which women or ethnic minorities are entering the STEM fields at the university level (AAUW, 2010). The IBO Statistical Bulletin does not give data concerning exam performance by gender.

High-stakes testing and performance by females has been the focus of much discussion in recent years. Advanced Placement (AP) results indicate that males outnumbered and outperformed females on AP tests in all STEM subjects, except for biology and environmental science, where girls outnumbered boys but were still outperformed. The participation and performance gaps are seen in the areas of calculus, physics and computer science (College Board, 2010). Girls also do not tend to perform as well as boys on the SAT in these subjects even though they do just as well or better in school (College Board, 2009, 2010; NCES, 2010). Girls worldwide take more International Baccalaureate (IB) exams than boys overall (nearly 58% in 2010). Unfortunately, the International Baccalaureate Organization (IBO) does not break down either participation or performance information in IB exams by gender or ethnicity in regards to subjects (IBO, 2010).

According to the National Council of Educational Statistics, US Black and Hispanic populations show wider gaps, both well below the OECD average. Socio-economic status (SES) seems to have a strong mediating effect, but when this is removed, there are still similar trends for ethnic minorities (NCES, 2009).

Gaps in International Secondary Schools in Math and Science Participation. For girls, the gap in performance on high stakes science and math tests does not seem to be only a US issue. These trends extend internationally to the recent Program for International Student Assessment (PISA) test for OECD countries. The PISA test is “an internationally standardized assessment that was jointly developed by participating nations and is administered to 15-year-olds in secondary schools. It tests competencies in reading, mathematics and science" (PISA, 2010). Worldwide, girls slightly outperform boys overall, but boys were seen as top performers more often than girls for both science, by a slight amount (1.1% vs. 1.8%), and math (3.7% vs. 6.8%). Girls were seen as top performers in reading (3.7% vs. 0.8%) (OECD, 2010). Of the twenty-nine OECD countries, the US ranked just a little below average in mathematics and just average in science for the countries tested. According to international findings in science and mathematics performance, (PISA and TIMSS [Trends in International Math and Science Study]) girls do not perform as well in math and science though this gap is closing. An interesting exception to this is the case of national schools in Iceland, where it seems that boys may be marginalized in several academic areas including mathematics and that cultural diversity within the country may be the reason for this gap (Halldorsson & Olafsson, 2009).

Little research can be found concerning the extent to which the international schools are identifying or addressing these gaps. More research in all types of schools, including international schools, concerning the participation and performance gaps, if any, might lead to a more complete picture.

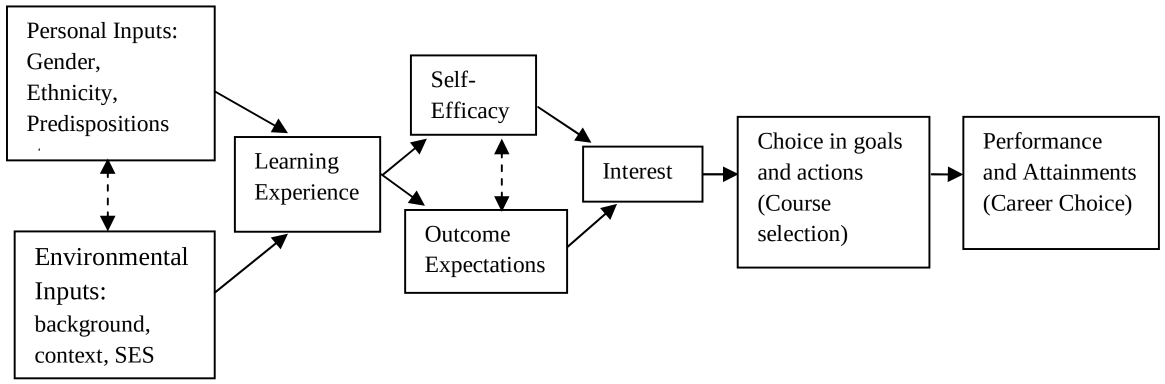
Gaps in Higher Education Science and Math Participation. In their book, *Still Failing at Fairness,* Sadker and Zittleman discuss a gender gap in science and mathematics participation in higher education (Sadker & Zittleman, 2009). Even though females and males are beginning to take STEM courses in US high schools at equal levels, few women pursue these majors in college, and female first year candidates are more likely to drop out of science and math programs (AAUW, 2008). This is confirmed again in the 2010 AAUW report. In physics, only 20% of the graduates are female. This percentage decreases further in graduate school and further in the workforce. The transition from high school to college seems to be the critical time when many young women turn away from a career path in science and mathematics. According to Kendall Powell, *Beyond the Glass Ceiling,* only eighteen percent of university professorships in scientific areas were held by women even though thirty-seven percent of the PhD's were earned by women. Ethnic groups fared far worse in these categories, where in 2007, four percent of college professors were African-American, two percent were Latino and less than one percent (0.7) percent were Native American (Powell, 2007).

In summary, there will be a need for an increased number of workers in the twenty-first century with backgrounds in the subjects of science, mathematics, engineering and technology. Nations must work together to address global problems. There is a decreasing number of US students interested in these fields at the tertiary level in the United States (AAUW, 2010). There are gender gaps as well as ethnic gaps, at least in the United States. Some of these gaps narrow when considering socioeconomic issues, but not all. This gap will put females and ethnic minorities at a disadvantage economically and does little to help fill society's academic and social needs in these areas. Finally, little research exists showing how, or whether, international schools are responding to address this issue.

Theoretical Framework

Lent's Social Constructivist Career Theory (SCCT) provides a useful model for studying career development. Career development theories can provide a framework for the study of factors concerning participation in science and mathematics academically. SCCT offers an approach to understanding the development of career choice and evolved from two previous theories, specifically a *trait model* developed by Holland, and *development models* like those of Savickas. Lent's career construction theory is a developmental model and explores how career development is molded via both personal constructivism and environmental constructionism. According to Savickas in, "The Theory and Practice of Career Construction", an individual goes through several stages during a career. These are growth, exploration, establishment, management and disengagement (Savickas, 2005). This current study is concerned with the growth and exploration phases of Savickas' model, while focusing on some of the tenets of Lent's theory. The theory allows for the study of barriers and supports that affect the self-efficacy needed to make academic and career choices (Lent, 2005).

The diagram below offers an overview of the Lent theory. It shows how individual inputs, including gender and race, interact with a person's background and environmental or 'contextual' factors to promote interest, support choice and influence performance in regard to career decisions. Most importantly he believes that the individual inputs combined with the contextual factors affect the learning experiences and therefore the person's self-efficacy and outcome expectations.



Adapted from Model of Person, Contextual, and Experiential Factors Affecting Career-Related Choice Behavior (Lent, 2005)

Lent has three interlocking models: choice, interest and performance. The choice model is used to show how sources of self-efficacy (person inputs, background) affect the learning experience. This leads to positive outcome expectations, and attainment, which will ultimately affect interests, choices and performance (Lent, 2005). This model considers factors that lead to participation in particular subjects.

The SCCT theory is concerned more with the psychological and social effects of gender and ethnicity than with the view of gender and race as categorical physical or biological factors. Individual attributes, such as gender and race, are linked to choice through the reactions they elicit from the cultural and social environment. Self-efficacy and outcome expectations do not,

> …arise in a social vacuum; neither do they operate alone in shaping vocational interest, choice or performance processes. Rather, they are forged and function in the context of important qualities of persons and their environments, such as gender, race/ethnicity, genetic endowment, physical health or disability status and socioeconomic condition (Lent, p. 107).

Overview of Factors Affecting Career Choice

In light of this holistic approach to development of self-efficacy, it is not surprising that literature investigating this STEM challenge reflects research in the areas of biology, sociology, and psychology. Educators are keenly interested in unraveling the current trends. One important point must first be made; it was brought up both by Tannen and again in the UK study (Murphy & Whitelegg, 2006) about the philosophy of studying these factors separately. Tannen, a sociologist, says in her book *Gender and Discourse,*

> I realize, however, that biological factors may be at work as well, and I would hope that even those who choose to examine them (of which again, I am not one) would not be branded by the ostracizing label "essentialist," a term that is often used as a sophisticated form of academic name calling (location 175) (Tannen, 1996).

Lent would disagree with separating the individual factors or inputs into discrete categories, because he stresses that the environment affects the individual. But research concerning academic success and interest does come from researchers operating in several distinct areas of study.

Psychological studies focus on cognition, anxiety and self-efficacy. Research findings related to TIMSS and PISA data sets show that as educational attention is paid to gender and ethnic differences, the gap decreases (Else-Quest, Shibley, & Linn, 2010; Sapienza et al., 2008). Cognition, though very important, is not the only variable to explain these gaps according to these researchers. Else-Quest discusses how paying attention to the differences in the United States has made a significant difference in decreasing the gap over time. Belief in one's cognition, or having a positive self-theory, plays a critical role in success in school, according to Carol Dweck. Dweck's theory is that students can hold a fixed or an incremental view of their own cognition. In her book, *Essays in Social Psychology*, she outlines the studies that led her to some enlightened and useful information about why some people give up and others do not (Dweck, 2000). Dweck's research leads to ideas about how stereotypes form and how praising intelligence backfires, especially for high achieving girls. Research findings also demonstrate how parenting plays an important role in the formation of self-theories and how the parent and child relationship offer important predictors of a child's social and psychological adjustment and academic success (Dweck, 2006, Eccles, 2005).

Mathematics anxiety has been extensively studied as a psychological barrier. In particular, researchers Else-Quest and colleagues have analyzed TIMSS and PISA data and deduce that female role models and peers may affect math confidence and choice (Else-Quest et al., 2010). Researchers from the University of Chicago indicate that a girls' anxiety toward math may be related to her elementary school teachers' anxiety. Boys however, do not seem to be as affected as girls. "Having a highly math-anxious female teacher may push girls to confirm the stereotype that they are not as good as boys at math, which in turn, affects girls' math achievement" (Beilock, 2011).

Social discrimination influences and outcomes are what Nieto calls the "hidden curriculum". Sexism, racism and even expectation of cognitive abilities, have been the focus of educational research for decades (Nieto, 1996; Sadker & Zittleman, 2009). Cognitive styles, according to Banks (in Nieto), can vary across cultures. Howard

Gardner and Nieto have gathered research to support this premise, as well as its implications for the classroom. Oettingen has also added important research, not only on the factors affecting individual efficacy, but also collective efficacies that affect groups using Hofstede's model (Oettingen, 1995). Tannen, at Georgetown, looks at the way culture and gender differences promote varying conversational styles, which in turn, influence peer - peer and teacher - student interactions (Tannen, 1996).

Currently, biological differences between genders are being extensively studied, especially with new methods of investigation, including MRI studies. An early researcher, Shors (2001), found that not only is the brain tissue different at birth in the two genders, but so is the brain function, including hearing, vision, spatial perception and feelings. Spatial perception, in particular, has been identified as a factor affecting the learning of mathematics (AAUW, 2010). Stress can affect anyone in terms of learning and cognition, which has important considerations for the classroom (Ratey & Hagerman, 2008). Further, female and male brains respond differently under stressful situations; females tend to react more negatively (Evans, 2001; Shors, 2001).

Context

There are two thousand one-hundred and fifty five International Baccalaureate schools which offer a unique opportunity to test the factors that may affect academic and career choice. There are IB schools in nearly every country which offer identical external assessments in most academic subjects, including math and science, and they share learner outcomes and learning objectives (Appendix A). The individual school has control over the delivery of the curriculum and this delivery may vary between cultures.

Externally moderated internal assessments for the IB are identical in all subjects to assure some level of comparison and are included in the final student score. IB schools can be both state and private, and both gender specific and coeducational. The size and age of the program and the experience of the personnel can vary among schools, but the philosophy, assessment criteria and curricular objectives of the IB are meant to unify the organization.

The IBO Mission Statement is prefaced with the following: “We promote intercultural understanding and respect, not as an alternative to a sense of cultural and national identity, but as an essential part of life in the 21st century”. The overarching goals are outlined in the mission statement:

> The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.
>
> To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.
>
> These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right (International Baccalaureate, 2010).

Schools that offer the IB program reputedly operate with a similar philosophy and curricular objectives. The assessments worldwide are the same, though offered in a variety of languages. The program is now offered in four languages of instruction, English, Spanish, French, and Chinese (2), though English is predominant. Further, the schools that use the IB program must go through a five year approval process, during which there must be reflection across standards, very similar to an accreditation. Standard C1 of the International Baccalaureate Standards and Practices, a curriculum review process for the IB, states: "A comprehensive, coherent, written curriculum based on the requirements of the programme and developed by the school, is available to all sections of the school community." Objective ten of this standard reads: "The curriculum is sensitive to cultural, gender, linguistic, ethnic and religious differences" (IB Standards and Practices, 2011). Analysis of gender and cultural equity is not found in the extensive statistics that are produced annually, nor is it found on the website (IBO, Statistics, 2010). This section can be found in Appendix B.

The IBO offers three levels of mathematics which track students into Math Studies (lower), Math Standard Level (intermediate), and Math Higher Level (advanced) areas of mathematics. Students must also take at least one science which can be drawn from two levels, standard and higher level. The science courses include Biology, Chemistry, Physics and Environmental Systems in Society (which is only delivered at the standard level). The program also has courses in Computer Programming and Design Technology.

The choices that international students make in high school may affect subsequent opportunities at the university level. Entrance into UK universities, for instance, is quite specific in the science and math courses required for entry into programs such as engineering and medicine. Choosing Math Studies (or even Math Standard Level) may indeed lead to a lower degree of preparation as far as these universities are concerned. Participation and performance in mathematics and science can affect available choices and preparation along the STEM path after high school in many countries.

Statement of Study Purpose

The purpose of this exploratory study is to investigate factors that influence participation of students in secondary science and mathematics subjects in IB schools outside of the United States.

Research Questions

1. What is the extent of student participation in science and mathematics courses in IB schools outside of the United States?
2. What factors affect the level of student participation in IB diploma courses in science and mathematics in international schools?
3. What is the relationship between student participation in mathematics and participation in science?

Key Terms

Culture. "Patterns of learned perception, behavior, attitudes and beliefs and that are shared by group of individuals" (Martin, 1994, p.10). Culture is a fundamental phenomenon. It affects not only our daily practices: the way we live, are brought up, manage, are managed, and die; but also the theories we are able to develop to explain our practices. No part of our lives is exempt from culture’s influence (Hofstede, 1997; IBO, Continuum, 2010).

International Baccalaureate. The International Baccalaureate (IB) is an educational and assessment program whose mission is to create a better world through education. The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect (IBO, Mission, 2009).

Participation. For the purpose of this study, participation in IB mathematics and science subjects will be defined as completion of examinations in IB *Group 5* subjects (Mathematics) and/or *Group 4* subjects (Science). Mathematics courses are taught at three levels: Math Studies, Math Standard and Math Higher Level. Two, four and six points will be assigned for these levels of math participation (Table 3.1). Students take one math course for the IB program. Group 4 subjects (biology, chemistry and physics) are taught at two levels- standard and higher. One through six points may be earned for science participation (Table 3.2). Students may take one or two sciences as part of an IB program. They may also take an additional science as a certificate if it fits within their schedule. The extent of science participation is defined as a combination of difficulty and number of courses.

Performance. Performance on IB tests is scored on a scale from one to seven, seven being the highest for each test taken. A percentage of each score comes from “internal assessment”, which for science includes 40 (SL) to 60 (HL) hours of documented laboratory work and a project or portfolio for the mathematics courses. (Performance is not the focus of this study.)

Self-efficacy. "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations." (Bandura, 1995, p. 3).

SCCT. Social Cognitive Career Theory was developed by Robert Lent. It is a tested and flexible model that looks at the impact of social and biological input on the psychological factors that may affect outcome expectancy and self-efficacy that affect interest, choice and performance. Its fundamental framework lies in Bandura's social cognitive theory which highlights the capacity of a human to make career choices while acknowledging personal and environmental barriers and supports (Lent, 2005).

STEM subjects. STEM is an acronym that refers to careers or academic courses in the areas of science, technology, engineering, and mathematics.

International school students: This term implies students attending schools using the IB curriculum outside of the US and Canada. These may be students in state or private schools.

Delimitations and Limitations

This study is an exploration of factors that influence the secondary level student participation in IB science and mathematics subjects outside of the United States. It therefore has several delimiters. First, it focuses on participation and not performance. While performance is an important discussion, this might be considered in a different study. Nevertheless, according to the social cognitive career theory, prior performance can be seen as a factor that influences later participation, so they are not unrelated.

Additionally this study is only concerned with students participating in the International Baccalaureate program, not other programs such as the A-levels in the UK or the Advanced Placement (AP) program. The reason for this omission is to control for important qualities of the school environment such as the philosophy of the program, and specific elements such as the curricular objectives and assessment procedures.

Delimitations also include the use of basic science courses (biology, chemistry and physics) and mathematics courses rather than other STEM subjects (Environmental Systems, Computer Science or Design Technology). While these data are available, many of the schools did not offer one or more of these programs, so by looking only at the basic sciences and mathematics offerings, more of the schools could be kept in the sample.

Another delimiter is the use of schools outside of the United States and Canada. The reason for excluding these schools is that much of the research in this area has been done in the United States. More information is needed on schools outside of the United States, especially international schools. Mexico is found in the Central American region for the UN, so is still within the sample.

Limitations exist in both design and methodology. The data comes from both the IBO world data and that of a single school. The IB data has limitations in that it consists only of data that is asked of the student or is contributed by the IB coordinator. The nationality data is discerned from passport data rather than ethnicity for schools outside of the United States. Prior math knowledge (PSAT data), parent occupation, as well as GPA data is not available for each participant in the world data set. For this reason, prior math, intended major, GPA, PSAT scores, parent occupation and influence of significant others was derived from one international school. In order to increase the sample size, three years of data (from the Admissions Office and the Counseling Center) was used. Interview data was delimited to students eighteen years or older.

With tens of thousands of students each year taking the IB examinations, this study is an exploration of how well International Baccalaureate schools do in fulfilling their objective on gender and cultural equity. While the IB world population data is robust, n = 34,984, both the quantitative data collected and interviews with students at one school (n = 194) will provide only a snapshot of individual factors that cannot be found by looking at the larger data set.

CHAPTER 2: LITERATURE REVIEW

Organization of the Literature Review

The organization of this literature review begins with evidence of the critical shortage of workers entering STEM fields as we move into the 21st Century. Research, then, extends to evidence for inequity in the STEM subject in terms of participation and performance, especially by gender and ethnic minorities. Unfortunately, much of the research in this area has focused on gender and not ethnicity. Most research is US based, but where found other countries are included. Of particular importance in this discussion is the participation of females and ethnic minorities in science and mathematics through secondary education and into the workforce. Limited information was found concerning student participation in science and math subjects in IB schools outside of the United States. Next, research investigating factors that may affect career choice is discussed. Lent's Social Cognitive Career model which provides a theoretical framework that combines trait and development models is explored in greater depth. By better understanding the factors that affect career decisions, educators and policy makers will be better able to make decisions that may encourage more students, especially women and ethnic minorities, to enter STEM fields.

21st Century Skills Importance of STEM Subjects and Skills

> *"Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century. That's why I am committed to making the improvement of STEM education over the next decade a national priority."* (Obama, in Eberle, 2010)

Why is the president concerned? Eberle (2010) describes the ten year employment projections from the US Department of Labor that show that by 2014, fifteen of the twenty fastest growing jobs in the nation will be in the STEM areas. The US is lagging behind much of Asia and Europe in terms of performance in both math and science as seen from international tests. Francis Eberle, president of the National Science Teachers Association says that the support for the president's "Educate to Innovate" program is designed to increase science literacy, create critical thinkers and promote innovation within the next generation. Innovation and literacy depend on a "solid knowledge base" in the STEM subjects. "The 2010 ACT College and Career Readiness report found only 29% of the tested 2010 graduates are considered college-ready in science and 43% are considered college-ready in math" (Eberle, 2010). President Barack Obama's speech to the National Academy of Science stated that the United States needs to increase student achievement in science and math as well as expand career opportunities for underrepresented groups including women.

Performance is not the only area of concern. Student participation in these critical areas is also worrying policy makers. Thomas Friedman, in *The World is Flat*, calls it the "quiet crisis". Citing the "marginal improvements" of US students on the 2000 TIMSS test, "The American education system from kindergarten through twelfth grade just is not stimulating young people to want to go into science, math and engineering" (p. 271). He quotes an article in *Education Week* that shows that sixty percent of the nation's top science students and sixty-five percent of the top mathematics students are children of recent immigrants (Friedman, 2005).

According to a study by the Bureau of Labor Statistics, the employment in science and engineering occupations will grow 70 percent faster than the overall growth for all occupations (TAP Coalition, 2008). The United States Department of Labor reports that there will be a shortage of workers needed for the rapidly expanding STEM jobs if significant, coordinated steps are not taken (Department of Labor, 2007). The government has committed millions of dollars to promoting a “STEM pipeline”. The US Department of Labor cites trends in K-12, and higher education science and math preparation, as well as changing demographics as serious challenges to finding a high quality and sufficient supply of “knowledge workers” with specialized skills required to meet our growing need. The need for workers of every level, from technical to graduate degree holders, is serious enough to elicit a response from the National Institute of Health (NIH), the National Science Foundation (NSF) and the Department of Education (DOE). The Department of Labor (2007) is committed to help orchestrate an organized approach among these federal agencies. One major concern is the participation of females and ethnic minorities. “The low engagement with STEM-related learning is particularly acute among minority, female, and lower-income students, who comprise a growing proportion of the total college-going public” (p. 2).

This is not only an issue in the United States. The United Kingdom (UK) is also having trouble recruiting qualified individuals into this area. Employment projections from a recent UK study commissioned by The Council for Industry and Higher Education and the Engineering and Technology Board concluded:

1) The continued shift towards a knowledge-intensive economy is expected to increase the demands for STEM graduates and postgraduates

2) The demand for most STEM subjects is likely to grow faster than for other disciplines over the coming decade.
3) Companies and organizations that are most dependent on high quality personnel will find it increasingly difficult to find the skills that they will require to operate and compete successfully.
4) If economics is going to be linked to highly technical jobs in the future, at least in OECD countries, then women need to be as prepared as men to enter the job market (Russell Group, 2009).

Further, the Royal Society has reported “the proportion of UK students on STEM postgraduate courses has not been increasing as fast as overseas students on these courses, and that this trend could lead to longer term skills shortages within the UK” (Russell Group, p. 5, 2009).

Need for Participation of Women in STEM Workforce

> *“Life in societies of today is undergoing accelerated social and technological change as well as growing global interdependence. These challenging new realities place heavy pressure on peoples’ capabilities to exercise some control over the course their lives take”* (A. Bandura, 1995).

According to the US Department of Labor, high technology careers are among the fastest growing and most well-paid positions. Women account for only about ten percent of the engineers, eight percent of the physicists and astronomers, seven percent of air traffic controllers and thirty percent of computer analysts (U.S. Department of Labor, 2007). Men are nine times more likely to hold jobs in these careers than women. Women continue to be paid as much as seventy three percent less than men for the same full time positions (AAUW, 2005; Betz, 2005). In considering these lower earnings, the average marriage in the US lasts seven years, and there are twelve million single-parent households, most likely headed by women (U.S. Department of Labor, 2007). Betz emphasizes that women continue to select from a smaller range of traditionally female, lower paid careers, and they make less money than men even when holding similar full time positions. The public perception is that women prioritize family over career, and that employers discriminate, or that employers are worried that women will leave in order to raise families.

> Women have made considerable advancements in the fields traditionally considered male. The most dramatic changes occurred in professional programs such as medicine, law, and business, where the proportion of women shot up from nine percent in 1970 to forty seven percent in 2000. Some economists, however, argue that women have the "wrong" educational credentials and skills and say that women are not sufficiently well educated in mathematics and science (AAUW, 2005, p. 6).

The National Science Foundation reported in 1998 that fewer than 20% of the bachelor's degrees in fields such as engineering and physics and fewer than 10% of the graduate degrees in education are earned by women (Kuh, 1998). Today, US women still lag significantly in undergraduate degrees in computer science and engineering but have made great strides in the natural sciences, surpassing males in the area of biology (AAUW, 2008; NSF, 2010).

Math as a Barrier

> *"Do not worry about your difficulties with mathematics; I can assure you mine are far greater."* (Albert Einstein)

The importance of a solid mathematical foundation in all STEM areas is generally agreed upon. Math prerequisites exist for most science and programming courses at the high school and college level. Lent described this as a "critical filter" for some of the best career opportunities in our society (e.g., engineering, scientific and medical careers, computer science, business, and the skilled trades) (Chipman & Wilson, 1985). Research concerning the factors that affect performance and participation in math education has been the focus of many studies. A classic study citing the importance of math to career was carried out at Berkeley (Sells, 1973) where it was found that four years of high school math was a prerequisite for entering calculus and statistics courses that were required for three-fourths of the major fields. Without this preparation, 92% of the females were not able to enter fifteen of the then twenty majors (Betz, 2005).

A more recent study by Nagy, Watt and Eccles (2010) across three nations (Germany, United States and Australia) found that there was a general decline in mathematics self-concept in all three countries from 7th through 12th grade. This longitudinal study includes research done by three different sets of researchers using instruments with similar theoretical framework and large samples sizes. "The present investigation was undertaken to provide more conclusive evidence on how cultural and institutional influences impact adolescents' academic self-concept, namely, mathematics self-concept" (p. 487). Males had a higher self-concept in each country, though the magnitude of the difference varied, with Germany having the greatest difference between the sexes. Nagy states that they also investigated the three different German school tracks and found that the results were similar to those found in the gymnasium (p. 501). (The gymnasium is equivalent to the high school academic course of study.) According to the authors, the most interesting finding was that these gender differences in math, English and sports-related activity decreased overtime. Males had higher self-concepts in math and sports and females had higher self-concepts in language. Gender differences in English increased until the eighth grade and then decreased. It can be found from both Nagy's and Jacob's study (2002) that largest differences are found between Grades 1 through 7. In Jacob's 2002 study, researchers tracked a student's self-confidence from elementary school through high school. Nagy suggests that repeating the study using identical measures, collecting data more often and across more cultural settings and educational structures, would positively add to the body of research concerning mathematics self-concept in regard to gender and culture (Nagy et al., 2010).

The TIMSS results showed that US students are lagging behind international students in improvement in math scores. The recent report from the National Assessment of Educational Progress (NAEP) reveals that only thirty-nine percent of the fourth graders, and thirty-two percent of eighth graders and eighteen percent of high school students perform at or above proficiency in science. This is of concern when eight of ten jobs in the next decade will require math and science skills (National Math and Science Initiative: Competiveness Brochure, 2010).

Several barriers have been researched concerning women and ethnic minorities in regard to career choice. They include math anxiety and avoidance, gender and occupational stereotypes, self-efficacy expectations, and a restricted range of interests (Betz, 2005).

Norma Presmeg, in her chapter "The Role of Culture in Teaching and Learning Mathematics" in the *Second Handbook of Mathematics Teaching and Learning*, focuses on the ethnomathematics. "Researchers now increasingly concede that mathematics, long considered value and culture-free, is indeed a cultural product, and hence that the role of culture – with all its complexities and contestations – is an important aspect of mathematics education" (p. 435). In particular, she emphasizes the influence of technology in mathematics and the use of mathematics and technology in the workplace as having a cultural dimension that affect how mathematics should be taught and how teachers' education needs to adapt (Presmeg, 2007).

> Given the importance of having an adequate math background to career options, females' tendency to avoid math coursework has been one of the most serious barriers to their career development. Further, it is fairly clear now from the research, that it is the lack of math background, rather than lack of innate ability that is to blame for females' poor performance on quantitative aptitude and mathematics achievement tests (Lent, 2005).

Gaps in US Science and Math Secondary Classrooms

In their recent 2010 report, "Why So Few?", the AAUW finds that, although US females have made great strides in achieving participation equity in many of the STEM subjects in secondary school since 1992, they still fall behind when it comes to performance and still do not choose to enter STEM academic tracks or STEM careers to the same degree as males. Further, although US girls and boys have reached parity in terms of participation and performance in math and science classrooms, girls do not perform as well as boys in high stakes testing. But, this performance gap is closing as well. In the 1980s the ratio of boys to girls who scored above 700 on the SAT Math was about 13:1; while currently this ratio is 3:1 (AAUW, 2010). These recent gains may indicate that the educational environment can do much to counteract the gender bias that exists. In her executive summary of the 1998 American Association of University Women (AAUW) report, "Gender Gaps: Where Schools Still Fail Our Children", Maggie Ford, then national president of AAUW wrote, "When equity is the goal, all gaps in performance warrant attention, regardless of whether they disadvantage boys or girls" (AAUW, 1998, p.1).

Gender and Ethnic Gaps for Secondary International Students

Much of the research regarding participation and performance in math and science internationally comes from the PISA and TIMSS tests. Top performers overall in the 2009 PISA were Finland and Korea (OECD, 2011). When looking more closely at gaps, Sapienza and colleagues found that there are gender gaps favoring girls in reading and favoring boys in mathematics internationally as well. Further they found that while the gender gap in math was closing, it was widening in reading. Korea showed a large gap in mathematics favoring boys, while Iceland, showed a mathematics gap in favor of girls in 2006. But what was most compelling was the relationship between Gender Gap Index (GGI) and mathematics gap. The GGI is a gender inequity index developed by the

World Economic Forum. Sapienza et al. found that the relationship was directly correlated. Findings indicate that countries with higher gender equity indexes had found ways to decrease the gap for girls in the area of mathematics (Sapienza, Guiso, Monte, & Zingales, 2008). In the most recent PISA test, 2009, the widest gap was seen in the UK, where boys earned about ten points higher than girls. Reporters for the BBC conclude that there were "significant" gender differences in the educational outcomes from OECD countries on the PISA test.

> The evolution of these differences provides some challenging issues for parents and educators. The influence of cultural beliefs in a country and the effect of the media were not considered in this report but are influences which cannot be ignored (BBC, 2009).

It is interesting to look at the case of Iceland in the PISA study because of the large gender difference in favor of females in mathematics, so this country might be considered an outlier to the trend of lower female achievement overall. Haldorsson and Olafsson at the Educational Testing Institute in Reykjavik analyzed the PISA results of 2000, 2003 and 2006 for 4th and 7th grade students, as well as national standard test performances of girls and boys. They noted from these findings that if girls do well in science, they are probably doing well in reading, math, science and problem solving. They found that gender differences across countries seem to be consistent. Further, they found that the size of the gender difference varies markedly across countries. Specifically, they noticed that the gender differences favoring girls in math increased through the 4th, 7th and 10th grade on both the PISA and the national exams. In order to uncover the reasons for why Icelandic females performed so well, they did their own study with this data. In their review of the Icelandic literature, they discuss Magnusdottir's research (2006) which shows that there are indications of gender-specific learning cultures where learning plays a different role for girls than for boys. Kristjansson's research (2005) found that Icelandic girls felt it was more important to do well in school than Icelandic boys (Halldorsson & Olafsson, 2009). To analyze these two longitudinal data sets more fully, they looked at how four factors, low vs. high stakes testing effects, regional effects, school variability and psychological factors influenced these gender differences. Briefly, they found that both the PISA and the national exams correlated well, so the national exams given yearly were also a good indicator in the study. The PISA was considered by the researchers to be a low stakes test and the national exams were considered high-stakes tests because they are linked to future outcomes. They found that the *low-stakes hypothesis* did not hold for Icelandic students; boys scored lower on average than girls. (The low-stakes hypothesis is that boys will outperform girls on high stakes testing and girls will outperform boys on low-stakes testing.) They also showed that the school-factor did not predict longitudinally the existence of a gender difference in that institution. The researchers found that fluctuations existed within the schools from year to year but overall the national gender differences stayed about the same. Citing an earlier study by Praz (2006), the cultural differences existing in Iceland remain relatively constant and exist across specific regions within Iceland. This study did not attempt to differentiate the students by regional culture, however. In terms of attitudes, the researchers found the girls' performances were linked more closely to self-efficacy and self-concept than were the boys' performances. Also they found that the learning culture, such as the relationship with the teacher or the competition within the classroom, was linked more closely with girls' performance than with that of boys. "School is more a personal issue for girls than for boys. Anxiety, self-perception and motivation are more linked with performance in school for girls and less so for boys" (Praz, in Halldorsson, 2006) Approximately one to four percent of the variance in the results on the PISA 2003 Math Test and PISA 2000 examinations could be explained by these personal factors according to this study. An important question asked by these researchers was why these higher marks earned by females don't "give them any advantage in the workplace, where males still get higher salaries, and higher positions within companies are filled by males" (Halldorsson, 2006, p. 61).

Gaps in Participation in Science and Math in Higher Education

Much of the US research on participation and performance today focuses on the university level and in the workplace. Females are underrepresented at the university in STEM programs. And, even if females enroll in a program, they tend not to continue, with only 20% of the STEM bachelor degrees earned by women. Females in graduate STEM programs are even rarer. Carolyn Garfein and Linda Hallman ask in the forward of "Why So Few?":

> Women have made tremendous progress in education and the workplace during the past fifty years. Even in historically male fields such as business, law, and medicine, women have made impressive gains. In scientific areas, however, women's educational gains have been less dramatic, and their progress in the workplace still slower. In an era when women are

increasingly prominent in medicine, law, and business, why are so few women becoming scientists and engineers? (AAUW, 2010, p. ix).

Gaps in Participation in Science and Math in UK Tertiary Education

The UK seems to be experiencing similar trends as US schools according to a report entitled "Girls in the Physics Classroom" by the Institute of Physics, authored by Patricia Murphy. This extensive study investigates how low participation in secondary schools affects participation at the university level. The UK has seen a thirty percent reduction in physics departments in the tertiary level since 1997. This study also looked at A-level participation by gender. The researchers noticed a drop in participation by both genders but most dramatically by females. Physics remained a higher interest for boys and the field held the least interest for girls. Researchers deduced that this will impact the workforce which includes physics teachers at the secondary level (Murphy & Whitelegg, 2006).

Findings from a study of five Irish universities show equally dismal results. Researchers found that girls make up only four percent of all students completing physics in tertiary school. At one university the "situation is also grim, with some institutes reporting less than seven percent female participation in physics based courses" (Chormaic, McLoughlin, & Gunning, 2005, p. 133). This lack of participation was also seen among the faculty at these institutions. Surveying the staff profiles, researchers found that only thirteen percent of the staff was female. Females were also underrepresented in senior positions within individual departments and in the administration of these tertiary institutes (Chormaic et al., 2005).

Individual Factors

Psychological considerations. Self-efficacy as a predictor of motivation was hypothesized by Bandura in 1977 and validated by Schunk and Hanson (in Bandura) in 1985 and 1987. Early research findings show that expenditure of energy and rate of performance were related to motivation. Further, findings indicate that teacher behaviors such as modeling and didactic forms of instruction increased self-efficacy and subsequent persistence to the task (Zimmerman, 1995). Bandura proposed that students with high self-efficacy would undertake difficult and challenging tasks more readily. Zimmerman cites research by Eccles (1990) and Betz (1989), who investigated the still prevalent trend of lower math test scores by females despite classroom success. This might indicate that there is a gender connection between self-efficacy and choice in mathematics. If so, this has implications for teachers to raise math self-efficacy in both males and females (Zimmerman, 1995).

Psychologist Carol Gilligan is known best, perhaps, for her work her 1982 study “In a Different Voice: Psychological Theory and Women's Development”. Gilligan took issue with Kohlberg’s research on moral development. According to Brown and Gilligan (1992), Kohlberg used only white males from upper economic levels of society for his research (Brown & Gilligan, 1992). While not a researcher in career development, Gilligan’s findings may be important in the discussion on efficacy. Gilligan interviewed girls at the all-girl Laurel School in Shaker Heights, Ohio, and reported that girls were “losing their voice”. They were, for instance, responding to questions with “I don’t know”, indicating a lack of confidence as early as ten years of age. This is mirrored in the testing results where girls leave blanks on critical tests like the SAT (Sadker & Zittleman, 2009).

Self-efficacy, according to Bandura has at least three behavioral consequences: approach vs. avoidance, quality of performance and persistence in the face of obstacles (Bandura, 1995). Betz found that college age women tended to score lower than men in self-efficacy domains having to do with math, science, computer science and technology, mechanical activities and physical activities (Betz, 2005). Therefore, it would seem math self-efficacy is related to performance and persistence of students enrolled in science and engineering programs.

According to Betz, gender and occupational stereotypes may in part come from how career counselors determine a match between the individual and the career. The segregation of interests on the Holland RIASEC interest survey may just be a result of socializing girls one way and boys another. The RIASEC refers to a commonly used personality profile that helps counselors in career planning. RIASEC refers to Realistic, Investigative, Social, Enterprising and Conventional. Women tend to score higher on social and artistic and males score higher on investigative and realistic (Lent, 2005). Betz discusses research which finds gender stereotypic socialization leads to restricted opportunities, regardless of potential. These restricted opportunities may lead to lower self-efficacy (Betz, 2005).

In a more recent study, elementary students were tested at the beginning and end of an academic year and their math achievement was correlated to the teacher's gender and level of anxiety. They found that female students were negatively affected by the female teacher's level of anxiety but that male students were not. These girls also showed a higher level of negative gender related ability belief, that “girls can’t do math” (Beilock, 2011). Research on stereotype threat (or the perception of operating in an environment with a perceived stereotype) shows that psychological factors play an important role in participation and performance in math related activities. Harrison’s study at the University of California showed that when lower income students were exposed to stereotype threat suggestions, their anxiety increased and their results decreased. Though their effort on the test was seen to be equal, their results were lower than those who did not receive the treatment. Their race was not seen to be a factor in this outcome but socioeconomic status was. (Harrison, 2006).

Sociological considerations. According to a study of the 2003 TIMSS and PISA results conducted at Villanova University by Nicole Else-Quest and colleagues, girls can perform at the same level as boys in math and science if supported by the right pedagogy and given female role models (Else-Quest et al., 2010). Else-Quest deduced that girls have less confidence in their mathematical abilities and this makes them less likely to pursue science, technology, engineering and mathematics at the secondary and university levels. "Stereotypes about female inferiority in mathematics are a distinct contrast to the actual scientific data reported in previous studies" (Else-Quest et al., 2010, p. 103). Part of the problem that females may encounter, at least in higher education, may have to do with organizational culture. AAUW (2010) cites workplace stereotyping and climate as a major factor in women not staying in certain academic areas in the tertiary level.

Myra and David Sadker, early pioneers in the study of gender equity in schools wrote in 1994:

> Mention educational inequality and, for most people, race comes to mind……while the record of racial injustice is at the forefront of our national conscience, history books still do not tell the story of profound sexism at school. Few people realize that today's girls continue a three-hundred year old struggle for full participation in America's educational system (Sadker & Sadker, 1994).

There has been much progress for females since Myra and David Sadker's first book, *Failing at Fairness,* was written in 1992. In order to reflect this new body of work, Sadker and Zittleman updated the research with a new book *Still Failing at Fairness,* which stresses that both boys and girls are subject to gender inequity in US public schools but also extends to more studies involving multicultural research findings and barriers for both genders (Sadker & Zittleman, 2009).

The Sadkers studied gender bias at the university level starting in 1970 and documented a stereotyped world of sexist textbooks with a world of "male accomplishment and female invisibility" (p. 175). STEM subjects at the university level still seem to be a male-world, according to the AAUW, where 98% of the engineering, 83% of the natural science faculty, 75% of the business, 60% of the humanities and 83% of the natural science faculty were male in 1995. This contrasts with the female dominated world of education in the US where 58% of the doctorates in education earned are by females. Still only 45% of the positions in these departments are held by women. Women enter a tertiary education system that is male dominated (AAUW, 2009).

Cultural considerations. The importance of multicultural education has been well established in the United States. Much of the study of cultural differences has dealt with the important implication to social justice as in Sonia Nieto's book, *Affirming Diversity* (Nieto, 1996). She suggests that recognizing diversity has educational implications that include "acknowledging the differences that children bring to school, including their gender, race, ethnicity, language and social class" (p. 136). She goes on to say that educators must admit to the possibility that these differences influence how students learn, and consequently provisions for these differences must be made. She warns that over generalizing can lead to "gross stereotypes" and "erroneous conclusions" about individual students, but these factors must be considered when analyzing human differences. Culture, she says, is neither "static nor deterministic but is just one important way in which to understand some differences among student learning" (Nieto, 1996).

One interesting and early finding by James Banks (1988) is that ethnicity is actually more important than socioeconomic status in determining cognitive style. Banks discusses the problems of studying social class and ethnicity. "Most of the literature that describes cognitive and motivational styles of ethnic students includes little or no discussion of social class or other factors that might cause within-group variations, such as gender, age, or situational aspects. Social class is often conceptualized and measured differently in studies that include class as a variable; this makes it difficult to compare results from different studies" (Banks, 1988). Banks found that ethnic differences persisted despite upward mobility. In his study, involving Black, Hispanic and Puerto Rican Americans, Banks concludes that more research needs to be done to investigate how "generational social class status" affects ethnicity across generations (p. 464).

In a multi-national research study published in 2009 with the 2003 TIMMS data, Nosek et al., found that "national implicit stereotyping of science as male was strongly related to national sex differences in 8^{th}- grade performance" (Nosek, 2009). This robust study used data from a half a million participants in thirty-four countries. Researchers looked at differences between mean scores for girls and mean scores for boys on the TIMMS 2003 and regressed them with data from Project Implicit at Harvard, which has collected data with an Implicit Association Test (IAT), from over 500,000 participants. Nearly three hundred thousand participants from around the world were used in a sub-sample that contained the thirty-four countries in the TIMMS study. The relationship was strongly correlated with an r of 0.60, 95 percent confidence interval. Further, the IAT data from Harvard study which contained over 500,000 participants found that seventy percent of men and women showed a tendency to associate male with science and female with liberal arts (Nosek, 2009).

Cultural variables may mediate successful participation within a learning environment. Tharp (in Nieto) suggests that four variables - social organization, social linguistics, cognition, and motivation - can affect the *communication style* between students and teachers. He suggests that cultural expectations, for instance in regard to wait time, acting out, student-teacher relationships and even nonverbal gestures, may influence this relationship (Tharp, in Nieto, 1989). Again, there are implications for classroom instruction and pedagogy.

Collective efficacy and culture. Bandura, in the chapter, "Exercise of Personal and Collective Efficacy in Changing Societies" stresses:

> developmental life paths are intimately linked to sociocultural environment in which people find themselves immersed….families and youth of today are going through times of drastic technological and social change that present unique opportunities, challenges, and constraints. Wrenching social changes that dislocate lives are not new in history. What is new is the accelerated pace of informational and technological change and the extensive globalization of human interdependence. These new realities place increasing demands on the exercise of efficacy. People's beliefs in their efficacy play a paramount role in how well they organize, create, and manage the circumstances that affect their life course (p.35).

Bandura feels that the "psychological barriers created by beliefs of collective powerlessness are more demoralizing and debilitating" than are external ones. Collective efficacy helps people "mobilize efforts and resources in order to cope with obstacles to make the changes they seek"(Bandura, p. 38, 1999).

Gabrielle Oettingen's 1995 work, though dated, is important because she links self-efficacy with these cross cultural perspectives. In her research, she used Hofstede's cultural dimensions to look at how culture may affect self-efficacy. Her premise is that children from individualist vs. collectivist cultures would self-appraise differently. Individualist cultures would place more meaning on individual success, and collectivist cultures would place higher regard on the needs of the group. She feels that this would impact teaching and learning. For instance, perhaps larger power-distance cultures would place more value on teacher-centered pedagogy rather than child-centered environments. In cultures with higher uncertainty avoidance, both students and teachers "desire rules and readily embrace them". Teachers would hold the answers and ambiguity would evoke stress. In contrast, individuals from cultures with weak uncertainty avoidance would be open to intellectual challenges and disagreements, teaching strategies could be more open ended and less structured. Finally, the masculinity-femininity dimension would also influence efficacy in different learning environments. In masculine societies, families stress "achievement and competition". Students who do well academically are the ideal, and subjects that promote professional careers are more valued. In feminine societies, social interrelatedness is stressed; grades are not as important and social adaptation is valued. Academic failure is not considered as serious in these cultures (Oettingen, 1995). Little research can be found associating Hofstede's dimensions with participation in math and science, but this literature provides some insight into possible consequences within a culture where math and science gender stereotypes prevail. Guiso's and Else-Quest's independent studies of PISA and TIMMS data attempt to fill this hole in the literature and to test the connection.

A 2008 study by Guiso, Monte, Sapienza and Zingales analyzed the PISA results and showed that in countries that were more gender-equal the math gaps tended to disappear for girls and the reading gap in favor of girls widened. They also found that the reading gap in favor of girls is much wider than the math gap in favor of boys. These gaps were correlated with the GGI of the country for girls, but were unaffected for boys (Guiso, 2008).

Else-Quest (2010) in her study, "Cross-National Patterns of Gender Differences in Mathematics: A Meta-Analysis" (2010), looked at past research investigating the trends in gender participation and performance in regard to culture and deduced that they have been based on North American samples, “thus it is unclear if these patterns of gender differences are generalizable to other cultures” (Else-Quest et al., 2010, p.104). This gap in the literature led Else-Quest and her colleagues to analyze the PISA and TIMSS data. In particular, they looked at the relationship between gender differences in math achievement, attitudes and affect. “Gender stratification” was not as evident in the achievement domain (other than in the area of spatial rotation). However in the attitude domain differences varied significantly across countries, cultures, enrollment ratios, and according to international measures of gender equity such as the GGI and Gender Empowerment Measure (GEM) (Else-Quest, 2010). An interesting finding was that math achievement and attitudes are positively correlated on the student level of performance, and they are strongly but negatively correlated at the national level of performance (Shen & Tam, in Else-Quest, 2010). That is countries with high math achievement tend to have students with less positive attitudes toward math overall. In an attempt to explain why there may be gender stratification within a society, Else-Quest draws upon Hoftede’s model of power-distances. “High power distance cultures (PDC) are inherently gender unequal, whereas low PDCs are inherently more gender equitable…that gender equity is negatively associated with gender differences in math attitudes …is consistent with this theoretical perspective”(p. 123).

Hofstede’s study (Hofstede, 1991) analyzed patterns of masculinization and feminization of careers. He looked at the distribution of women in careers in different nations and found that females “dominate doctors in the old Soviet Union, dentists in Belgium and shopkeepers in West Africa. Men dominate typists in Pakistan and form a sizable share of nurses in Netherlands” (p. 81). He did find trends, however, across societies in terms of gender roles. Men, according to Hofstede, are more assertive and competitive and women more nurturing and concerned with relationships. Carol Gilligan (1992) shared this finding. She found that females have more of a commitment to caring relationships, and men focus more in terms of rules and justice (Brown & Gilligan, 1992). She feels that both ideals should be valued by society. Hofstede found that across cultures, traditional and modern, there is a sense that men are supposed to be concerned with life outside the home and women more concerned with life within the home (p. 81). This, he surmises, is a natural role pattern stemming from women delivering and caring for small children, which impacts the role models that young children have and affects their mental software. Different cultures have varying masculinity indexes however. Hofstede found that roles that required competitive climate (such as sales) were dominated by men. Scientists, engineers and technicians, which focused mostly on individual technical performance, called for masculine values and were dominated by men (Hofstede, 1991). Oettingen (1995) goes on to say that:

> Cross-cultural research needs to be extended to the effects of societal practices in the family, the community, and the workplace on self-efficacy appraisals. The links between cultural differences and their expression in these various institutions have yet to be established empirically. Finally, available evidence indicates that efficacy beliefs have similar effects on human functioning across cultures. (in Bandura, 1995, p. 171)

Biological considerations. Spatial training has received much attention from the AAUW reports and the reason behind this is found in brain research. Boys process spatial problems differently than girls. While boys use their hippocampus (a primitive area) and cognitively ‘map’, as seen on MRIs, girls use their cerebral cortex, which requires language input. Girls need landmarks and boys can use direct Euclidean cues.

Spatial processing was researched as early as 1978 by John O’Keefe and Lynn Nadel (Nadel & O'Keefe, 1978). Nadel’s research showed that the hippocampus is prewired for spatial geometry, but since he only studied males, his research fell short of telling the whole story. Research at the University of Ulm, Germany, has shown that females will perform as quickly as males if given the cues in a context they understand (Gron & Riepe, 2000). Gron had subjects play with virtual reality games while connected to MRI brain scanners. He found that females used the cerebral cortex to navigate the maze while males used their hippocampus. They used completely different parts of the brain to play the game.

Geometry and number theory are learned differently by each gender. In a study involving 1300 undergraduates, researchers factored out SAT scores and showed that gender differences still existed in terms of computer experience. Furthermore, they found that increased experience mediates the gender difference in spatial ability observed on the Mental Rotations Tests. Terlecki suggests that girls tend to use their cerebral cortex and require more descriptive understanding, while boys tend to use their hippocampus. This implies that explanations in these areas may need to be based more in language and examples for girls, and for boys they can be more abstract. A purely mathematical approach may be difficult for girls. It has been shown, however, that girls respond very well to spatial training and when the environment is adapted to their learning needs (Terlecki, in AAUW, 2009).

Stress response and anxiety may be other factors affecting individual in a learning environment. According to Evans (2001), girls produce acetylcholine and boys produce adrenaline when placed in stressful situations. Females' autonomic nervous systems are shown to be influenced more by the parasympathetic nervous system rather than the sympathetic nervous system found in males. As a result, girls feel ill and boys feel exhilarated as a result of the stress response (Evans, 2001). Stress seems to improve learning in boys but decreases learning in girls. Shors, at Rutgers, and her colleagues at Princeton and Rockefeller University, have shown that stress increases neural connections in the male hippocampus but has an opposite effect on females. This is because stress enhances the growth of neural connections in the male hippocampus but inhibits the growth of the female hippocampus (Shors, 2001). The possible result is that girls will not like fast paced, high-pressures situations with time constraints (like high-stakes testing) while boys may enjoy this.

Gardner, Nieto, Bandura and more recently Droidge have written books that concur and may shed some light on Nosek's research. Howard Gardner suggests in his book, "Frames of Mind: The Theory of Multiple Intelligences", that individuals differ in the range of intelligences. Intelligences are defined by Gardner as "the ability to solve problems or develop products that are valued in a particular cultural setting" (Gardner, 1989). Gardner argues that intelligence is a result of biological and cultural factors. While neural synaptic development for the various intelligences occurs in different parts of the brain, culture also determines which learning will get reinforced. This finding is supported by Norman Droidge, 2007, in his study of neuroplasticity and culture. In his book, *The Culturally Modified Brain*, he describes how culture shapes the mind. As cultures evolve, they continually lead to new changes in the brain. He cites examples of the nomadic Sea Gypsy's adaptation to underwater vision and the enlarged areas of the brains of musicians, artists and even taxi cab drivers. He calls these "signature activities" because they require "training and cultural experience" and are shown to affect brain structure and function (Droidge, 2007, p. 290). Again, while care must be given not to stereotype cultures according to Gardner's Multiple Intelligence theory, it is still important to understand that individuals do display differences, and trends can be seen across cultures.

Environmental Level Factors

School size. Many factors may be involved in the study of effect of school size on participation and performance. Some factors may be socioeconomic status of the community, grade-span configuration (number of grades within the building), educational level (elementary vs. secondary), sector (private or public), location (rural vs. urban) and curricular focus (comprehensive vs. special purpose) (Howley, Strange, & Bickel, 2000). An important series of research done in the US called the "Matthew Project", focused on the effect of SES and school size on performance. A series of related research projects began in 1988 and continued through the 1990's, attempted to validate the original 1988 research and study the effect of school size under a range of schooling conditions in the United States. Factors included ethnicity, locale, SES, region and school district organization. In the end, seven states were used and principle findings indicated that affluent schools had higher effect sizes with larger schools but impoverished schools showed negative effect sizes with larger schools. In his research summary, Howley concludes that schools that are very large, say over 1000, may be “unwise for any community”, but that communities with a low SES would benefit most from smaller school sizes (Howley et al., 2000).

A study published in 2000, looked at the effect of school size of sixth and eighth grade programs in Chicago. It used a modeling technique to test the effect of school size on teacher attitudes and mathematics achievement scores. Data came from survey and test information from 23,000 sixth and eighth grade students and nearly 5000 teachers. Lee and Loeb found that a smaller school led to more positive teacher attitudes and to better student performance outcomes (Lee & Loeb, 2000).

In the last twenty years, participation in physics and computer science has been declining in the US (NCES, 2001). This phenomenon has also been seen in the UK and Ireland, as noted earlier. The National Foundation for Educational Research in the UK was commissioned to study the effect of school size and type on academic performance. The study included 2954 high schools in England and the results were released in 2002. The findings were that girls did better in single-sex comprehensive schools and that boys did better in selective schools. The second finding was that girls in single-gender classrooms were more likely to take advanced math and physics and boys were no more likely to take female – associated classes, such as cooking. Finally, schools of medium size seemed to do best because smaller schools may lack course offerings especially at the advanced levels, and student performance appeared to suffer in larger schools. Their conclusions were that in order to maximize student performance, moderate class sizes of 180 students and single sex environments should be adopted (Spielhofer, O'Donnell, Benton, Schagen, & Schagen, 2002).

Gender specific schools. An Australian study by the Australian Council for Educational Research (ACER) included over 270,000 students, in fifty -three academic areas, showed that girls and boys scored an average of twenty-two and fifteen percentile points higher in gender specific schools than did girls and boys in coeducational classrooms, respectively. This study also reported fewer discipline issues and concludes that coeducational settings may be limited in their capacity to differentiate for a wide variety of learning styles of both boys and girls (NASSPS, 2009).

In a New Zealand study involving over thirty-seven schools and fifteen hundred students, looked at the effectiveness of single-gender versus coeducational status on achievement in English, math and science. Harker found that girls in single-sex schools performed better than those in coeducational schools. But, when he controlled for SES, ethnicity and prior achievement, these differences vanished (Harker, 2000). He also looked at both enrolment (participation) and performance and found that girls outnumber boys 2:1 in biology and boys outnumber girls 2:1 in physics.

A doctoral dissertation by Jeanette Elam (2009) entitled, “An examination of single-gender and coeducational classes: Their impact on the academic achievement of middle school students enrolled in mathematics and science at selected schools in Georgia” used 304 middle school students in four different schools, and aggregated data according to male and female, and white and black American students. Students in single-gender schools of both ethnicities performed similarly. She found that white students outperformed black students in both settings and coeducational students outperformed gender specific students on an external test. She supported the assumption that single-sex environments were more effective for females than for male students (Elam, 2009).

Significant-other influence. Jacqueline Eccles, the Director of Gender and Achievement Research Program at the University of Michigan, has both studied and accumulated research that shows that parent education influences children's success. She cites her own and others' research when discussing possible reasons for this connection (Eccles, 2005). Research by Hoff (in Eccles, 2003), shows that parents with more education both talk to and use more complicated and varied language. This predicted higher reading skills. Results from Alexander (1994) showed that parents with more education have higher expectations which can be linked to greater educational attainment for their children. Furstenberg (in Eccles) in 1999, carried out research that showed that children whose parents had higher education had more exposure to educational opportunities, such as music lessons science and computer programs, and summer camps (in Eccles, 2005). In an earlier study (1983), Eccles found that parents of boys rate talent as a more important cause of their child's math success than do parents of girls; parents of girls rate effort as more important" (in Eccles, 1986).

Parents' involvement in science homework may also be a factor that affects self-assessment in children toward science. Bhanot and Javanovic analyzed both mothers and fathers involvement with boys and girls science homework and looked at the child's belief over time. They found that mothers' involvement was related to a positive self-assessment for girls, while it was related to a negative self-assessment in boys (Bhanot & Jovanovich, 2009).

One of the early pioneers in self-efficacy studies, Hackett, found that math self-efficacy is influenced by a combination of gender-related socialization and math preparation. The role that teachers play in explaining math related behavior is one exogenous variable that Hackett says might provide more explanatory power to her early model developed using college level students and measuring mathematics self-efficacy (Hackett, 1985). Soon after, Thomas Dee did a study with National Education Longitudinal Study (NELS) data from 1988 and published his results in 2007. He looked at the effect size of having female teachers on the test scores of students in four academic areas - math, science, English and history. Dee's results showed that having a "female teacher raised the achievement of girls by a statistically significant .045 standard deviations but lowered the achievement of boys by a similar and statistically significant amount" (Dee, 2007, p. 545). In part of this study, he showed evidence that female teachers were more likely to be assigned to students with lower math achievement.

Social Cognitive Career Theory

Investigating career choice is, according to Robert Lent, "like a giant jigsaw puzzle. The puzzle includes pieces such as genetic endowment, environmental resources and barriers, learning experiences, interests, abilities, values, personality, goals, choices, satisfaction performance, change over time and multiple transitions"(Lent, 2005, p. 101). His theory, called the Social Cognitive Career Theory (SCCT), offers an adaptable framework to analyze how people develop vocational interests, make occupational choices, and achieve stability in those choices.

The foundation of the theory lies in Bandura's Social Cognitive Theory which looks at how a person's behavior and environment influence one another (A. Bandura, 1986). Bandura's theory is closely aligned with Dweck's attribution theory which helps to explain "learned helplessness" as well as her concept of a self-theory being either incremental or fixed (Dweck, 2000). The SCCT framework connects people's capacity (self-theories) to direct their own career path with the understanding that there are many barriers and supports that affect self-efficacy (Lent, 2005).

Three "person" variables are important when considering SCCT: self-efficacy beliefs, outcome expectations, and personal goals. Self-efficacy refers to "people's judgments of their capabilities to organize and execute courses of action required in attaining designated types of performances" (Bandura, 1986, p. 391). In SCCT, this factor is considered a dynamic set of self-beliefs. According to Lent, self-efficacy is acquired and modified via four primary informational sources: personal or performance accomplishments, such as success in coursework; vicarious learning; social persuasion from parent and peer input; and physiological and affective states. The first source, personal or performance accomplishments, has the greatest influence on self-efficacy (p. 104).

Outcome expectations are an individual's beliefs about the consequences or outcomes of performing particular behaviors. Self-efficacy is more influential than outcome expectations in situations which call for complex skills that may be costly or difficult, for example pursuing careers in medicine. But looking at the interaction of these two variables is important. A person may have high self-efficacy but low outcome expectations. Betz (2005) discusses this in regard to women or students of color who are confident in their capabilities in, for instance, math or science, but who refrain from elective courses or advanced studies because of "negative expectations of how they would be treated" (Betz, in Lent, p.105). So, both outcome expectations and self-efficacy affect choice. Personal goals are supported by *choice* and *performance* in SCCT. What type of activity or career does the person desire? And, what level of performance do they plan to achieve? Choice and performance expectations are affected by and affect self-efficacy and outcome expectations. Strong self-efficacy and high outcome expectations nurture personal goals.

SCCT involves three process models (Lent, 1994), the development of academic and career *interests*, the formation of educational and vocational *choices*, the nature and results of *performance* in academic and career spheres. Each model has the three basic theoretical elements: self-efficacy, outcome expectations, and goals. These three basic elements work "in concert with other important aspects of persons (e.g. gender, race/ethnicity), their contexts, and learning experiences to help shape the contours of academic and career development." (Lent, p. 106)

Persistence is a key factor that leads to success in academic and career settings, but other factors such as opportunities to pursue career paths and interest shifts may impact performance as well. Of the three process models described by Lent, the *choice model* may supply the most meaning for this study. This model can be used to analyze how the person's background and personal inputs (gender, race/ethnicity, disability etc.) may affect their learning experiences which in turn will affect both self-efficacy and outcome expectations. Like the other models, these two variables will affect the interests and goals. With the choice model, these goals will lead to actions and, in turn, affect performance and career outcomes.

The *choice model* is divided into three component parts: the expression of a primary choice (or goal) to enter a field, the individual's actions to implement this goal, and subsequent performance experiences that shape the individual's future choice options. Lent warns that this process is not unilateral. While people can choose career paths, the environment also chooses people. Barriers can exist that prevent people from attaining career goals. Some possible barriers might be funding, family or cultural influence, or quality of prior education. For instance, a person may find that the reality of completing a course of study may be too difficult and may change their intended path. The model therefore is dynamic and will be highly individualistic because it considers the environmental barriers and supports (Lent, 2005).

The *performance model* looks at past ability and performance (grades and academic success) in the development of self-efficacy and outcome expectations. These lead to performance goals and attainment. So persistence to the task at hand is enhanced by past success. We can see in the *choice model* this idea is subsumed. Performance attainment reinforces learning experiences. The *interest model* could also be used to analyze gender and ethnic influences on self-efficacy and outcome expectations. Interests will allow for the production of skills that are in line with the social role expectations (Lent, 2005). This has cultural implications as well. The important insight from this career literature is to show that an integrative approach of biological, social, cultural, and psychological factors is necessary in any study looking at the barriers and supports leading to career choice.

Social Cognitive Career Theory, current research and practice. The focus of this research is to investigate factors that influence participation in science and math courses. Choice is central to this study. Individual variables, gender and cultural attributes (nationality and ethnicity), are two major factors that have been shown to affect choice (participation) and performance in STEM subjects. This study looks indirectly at self-efficacy, outcome expectation and goals, by looking at the choices that students make in regard to course selection. Gender and ethnicity are two major individual or "person" factors that may interact with environmental factors to support or block participation. Stereotype-threat, as outlined by Dweck, is a perception that there is inherent bias which may act as a barrier to academic choice or career plans and may result as the individual interacts with his or her environment. Environmental factors come from different domains: home, school, and country in terms of international schools abroad. Performance is not the focus of this study. But prior math performance as seen by a test such as the PSAT or prior academic success as measured by the GPA might be factors as both cognition and belief in one's cognition can influence choice, interest and performance.

Females and people in ethnic minorities are not participating fully in academic majors and subsequent careers in the areas of math and science. Betz and Hackett were the first to test the self-efficacy model in 1981. They found that self-efficacy is stronger in women pursuing traditionally female dominated interests (Hackett, 1985). Lapan, Boggs & Morrill (1989) showed that self-efficacy can explain gender differences in scientific and technical fields. Is this "gender-stratification" evident in international schools? Bandura observed that "cultural constraints, inequitable incentive systems, and truncated opportunity structures are…influential in shaping women's career development" (Bandura, 1997, p. 436). Program factors may also influence choice. For instance, small programs that are not well developed may not offer as many courses and therefore lead to lack of participation because of "truncated opportunity" for males and females. Bandura shows that socially imposed barriers lead to self-beliefs that become obstacles for women. Oettingen's work indicates that cultural barriers, both implicit and explicit, will affect choice.

Lent has shown this framework to be helpful in the study of career choice for high school students in international contexts. Most recently Lent verified his model in secondary state schools in Portugal, so the model has cross-cultural validity (Lent, 2009). In Portugal, Lent and colleagues tested the SCCT choice model using a sample of six hundred high school students (Lent, Paixao, Silva, & Leitao, 2009). Students completed several inventories, including the RIASEC, involving the choice model. Specifically researchers were trying to show that self-efficacy is predictive in outcome expectations, that together they predict interest and influence goal setting, and that supports and barriers account for the variance seen. This reflects the underlying premise to the theory, as Bandura hypothesized, that self-efficacy is influenced by environmental supports and barriers. The results showed that student self-efficacy, interests and outcome expectations relate to choice. It is therefore important to look at what factors might serve as supports and barriers to promote self-efficacy that will boost interest and outcome expectations. While all themes on the RIASEC scale showed substantial interaction, 'investigative' showed the highest correlation with self-efficacy. One interesting finding from the Portugal study was that Bandura's indirect pathway was more supported than was the more direct SCCT model. It appears that "the main function of social supports and barriers may have been to inform self-efficacy which, in turn, produced either a direct path to choice consideration or an indirect path through outcome expectations and interests" (p. 249). According to Lent, meta-analysis is beginning to provide a strong support for the all three models within the SCCT. Lent indicates however that additional research is needed to help clarify "how social cognitive variables operate together with culture, ethnicity, socioeconomic status, sexual orientation, and disability status to shape the career development of students and workers" (Lent. 2005, p. 116).

The social constructivist theory has also begun to affect the way counselors are working with students making career decisions. The concept of developmental-contextualism is a framework that underpins School-to-Work-to-Life (STWL) programs outlined by Solberg et al. It shows how counselors are using the social constructivist theory in practice. The School-to-Work-to-Life Act (STWLA) of 1988 passed "in response to the changing nature of the world of work and the increasingly high-level skills needed to compete for occupations offering livable wage" (Solberg, Howard, Blustein, & Close, 2002). They point to the social constructivist work of Lent, Hackett and Brown and others as spurring changes in their field of career development. Specifically, research surrounding career development has caused a paradigm shift from focusing on a person-environment fit model to a more developmental model, where personality traits do not remain stagnant over time but are dynamic and changing. "The STWL paradigm challenges practitioners to move from individual levels of intervention to systemic and contextual change efforts. Within the STWL model, there are many interacting systems (i.e., school, family, work, and community, etc.). Changes at the system level will ultimately affect individuals within these systems, and it is therefore important that clinicians target their interventions toward systems"; further, the assumption of their framework, developmental-contextualism, is that there is a mutual effect of the "person and context". Students "activate dispositions, skills, and beliefs associated with their student self-concept automatically through feed-forward processes: that is they actively seek and organize information that confirms their previously developed student self-concepts" (Solberg et al., 2007, p.711). Understanding and then promoting successful learning experiences will, in effect, promote future successful learning experiences.

Summary

There is a need for interested males and females to enter science, technology, engineering and mathematics (STEM) fields around the world. Pressures of the twenty-first century show a need for highly-skilled, well rounded individuals, capable of solving some of the world's challenges. Females and ethnic minorities in particular need to not only be successful academically in high school in mathematics and science areas but need to stay within these majors and choose STEM career paths in greater numbers in order to meet this need. US Department of Labor statistics indicate that if individuals, either male or female, don't participate fully they may be left further behind economically and our ability to address the complex problems of the future will be hindered (Department of Labor, 2007).

Self-efficacy seems to be a key factor in career choice according to many researchers (Lent, Eccles, Dweck, and Oettingen) involved in career development and aspiration. Two stages of career development, exploration and growth, are important in this study. Self-efficacy in choosing a career path may be a prerequisite for achieving performance goals, according to the SCCT framework. The SCCT model is helpful because it integrates both traits and developmental concepts. This model illustrates how unique developmental inputs, biological, social, cultural and psychological, interact with the environment and lead to both supports and barriers, both intrinsic and extrinsic, in regard to career choice.

Self-theories may provide some insight into psychological differences. According to Dweck, the personal assumptions about one's own intelligence, whether fixed or malleable, can lead to choices (Dweck, 2000). According to Dweck, high achieving girls are at particular risk due to an entity or fixed view of intelligence which makes them vulnerable in high stress situations where their intelligence might be questioned. This quality may lead to an environment where it is difficult for females to navigate in male dominated fields or courses (AAUW, 2010). Research into parental influences (Eccles, Bhanot), and teacher influences (Dee, Else - Quest) have been implicated in performance outcomes for students. Peers also have been shown to have an impact on whether girls, in particular, take certain courses or not, but this research is limited. Else-Quest's (2010) research on TIMSS and PISA results of 2003 did show that the gender ratio, in favor of girls, in a program had an effect on their performance. Also, she found that peer choice in class was influential in participation.

Socially, students bring differences to school which need to be understood by educators. Nieto points out that educating with these differences in mind is important for full participation. Early work by Banks (1988) shows that ethnicity may be more important than socioeconomic status in determining cognitive style (though Harrison (2006) found that the reverse was true in regard to stereotype threat). Gardner's theory of multiple intelligences corroborates Bank's idea. Gardner and Lazear (in Gardner) point out that differences in learning as well as preferred assessment may affect performance. Bandura suggests that external social variables and events also affect a person's ability to be successful. In his book, *Self Efficacy and a Changing Society*, he states that the sociocultural environment is linked to a person's life path. Further, the rapid changes in today's society must be considered as increasing demands on a person's self-efficacy. Oettingen's and Else-Quest's research links Hofstede's cultural dimensions to self-efficacy.

Spatial perception and stress response may affect performance and persistence in math and science, especially among girls (Nadel & OKeefe 1978; Gron, 2000; Evans, 2001; Shors, 2001). Spatial perception can be trained and pedagogical changes may help narrow these differences (Terlecki, 2009). Stress and anxiety seem to be important factors in choice of course subject and difficulty. If so, then insights into classroom environments and perceived environments, as well as teacher, peer, and parental influences are important.

International school data may offer a unique opportunity to investigate participation in science and mathematics. IB schools worldwide offer common curricular objectives and assessment criteria, as well as an overarching philosophy. Longitudinal data for both gender and nationality in STEM subjects is accessible. Evaluating a data set that consists of all regions of the world and nearly all nationalities may shed some light on the patterns of participation. Individual factors, such as gender and nationality, may interact with environmental and school factors such as school size, type, coeducational status, and others, to encourage or discourage students from entering science and math subjects. Research into these interactions may offer insights and lead to further research as well as to implications for practitioners.

CHAPTER 3: STUDY DESIGN

Statement of Study Purpose

The purpose of this exploratory study is to investigate factors that influence student participation in secondary STEM subjects in IB schools worldwide.

Research Questions

1. What is the extent of participation in science and mathematics courses in IB schools outside of the United States?
2. What factors affect the extent of participation in IB diploma courses in science and mathematics in international schools?
3. What is the relationship between participation in mathematics and participation in science?

Rationale for Methodology

A mixed-methods approach is used in this study. "The problems addressed by social and health researchers are complex, and the use of either quantitative or qualitative approaches by themselves are inadequate to address this complexity" (Creswell, 2008, p. 203). The purpose of this study is to investigate factors that influence secondary student participation in STEM subjects in international schools as well as possible underlying reasons for the results found. Because there were three sources of data, a "concurrent embedded strategy" seems most relevant. This strategy is one in which a "primary method guides the project and a secondary database provides a supporting role in the procedures. The secondary method is given less priority and, whether quantitative or qualitative, it is embedded, or nested, within the predominant method; the secondary method addresses a different question than the primary method, or seeks information at a different level of analysis" (Creswell, 2008, p. 214).

Population sets from the International Baccalaureate Organization (IBO) and from a single school were used in this study. As emphasized by Hirschi and Selvin (1973), when researchers have surveyed an entire population, then all statistical values obtained are population, not sample, values. Since statistical inference is not an issue, statistical tests of significance are not technically needed. However, statistical tests of significance in this study are reported for two reasons: 1) for their heuristic value and their common use in statistical studies, and 2) there is indeed a number of potential models to explain these data and the model tested. Therefore they could be considered a sample from a population of models. In that sense, the statistical tests of significance are appropriate (Hirschi & Selvin, 1973).

There are two reasons that semi-structured interviews, rather than surveys, were used to collect data concerning the influence of significant others. Feminist research indicates that surveys, which can be highly convergent, and may not be appropriate for female responses (Mertens, 1998). Also, the nature of these factors necessitates an open-ended response. The interviews do include some forced response items in terms of ordering the influence of significant others. Participants are required to place cards with words "parent", "teacher", "counselor", "peer", or "other", in order of influence and then discuss their reasons for doing so. This allowed them to critically evaluate their responses.

IBO World Data and Data Collection

Participation in IB subjects implies that students have completed both internal and external components of the IB. Internal assessment is obtained in the classroom by the teacher. In order to receive an IB score, the student must have completed the internal assessment prior to taking the external examination. Together these components ensure that the objectives are adequately and appropriately assessed.

Internal assessments are randomly sampled from each IB course before the exam period begins. Science student work is assessed against common laboratory criteria, which is the same for Standard and Higher Level courses. Students must be able to design their own experiments, collect and analyze data, and evaluate and conclude on results in order to receive full marks. Higher Level students must complete a total of sixty-four lab hours and Standard Level students must complete a total of forty laboratory hours (IBO, Diploma Program, 2007). Mathematics students must complete two portfolio assignments. Math Standard Level includes two assignments, one concerning "mathematics investigation" and the other "mathematics modeling". The portfolio is to take ten hours of the Standard Level (SL) and Higher Level (HL) program and twenty hours of the Math Studies program. Internal Assessment (IA) is integrated into all courses (IBO, Math Studies, 2004; IBO Math Standard Level, 2006; IBO Math Higher Level, 2006).

Ongoing and regular curriculum reviews "ensure that the latest developments in research and theory are incorporated into what students are learning". Students taking a full IB diploma will take assessments in six "Groups", or academic areas, in order to insure a well-rounded curriculum. The Groups include courses in a student's first language, a choice of a second language, individuals and societies, mathematics or computer science, experimental sciences, and the arts. At least three exams must be taken at the higher level. The last group allows for some flexibility, where students may choose an additional language or science, in order to ‘pursue areas of personal interest or to meet university requirements” (IBO, 2007, p. 2). Assessments in all of the six areas are designed to emphasize the development of higher-order cognitive skills and are based on student performance against a set of course objectives. Criterion-referenced, these exams are designed to test a student’s ability to “think analytically, and critically, to integrate and apply their learning, to work collaboratively and to communicate what they have learned in writing and orally” (IB Brochure, 2011).

There are over sixty-five thousand trained examiners worldwide who facilitate the development, the marking and the moderation involved in the assessment process – both internal and external components. These examiners are moderated, or invigilated, by a deputy moderator who in turn is moderated by a chief moderator to ensure consistency in marking. There are two testing periods, May and November. Students take tests over a three week period on designated days for their region (IBO, 2011).

Data Set 1: IBO Data

Data collection. The study includes three data sets. The first data set was collected by the International Baccalaureate Organization (IBO) during the examinations in 2009 and 2010. IBO World data was used to investigate some of the factors influencing participation in math and science outside of the United States. In order to receive these data, a data sharing agreement was organized between the researcher and the IBO. The statistics office of the IBO organized the data and then worked with the researcher over a period of three weeks to ensure that all necessary data was delivered on Excel spreadsheets, which were saved to a secure location; the process was completed via email. The data set used for this study includes all students taking the exams in May and November of 2010 as well as participation information of exams these same students took in 2009, if any. Different academic calendars dictate which exam periods are chosen by a school. Three levels of data were received from the IB: individual data, school data and country codes. Individual student data such as gender, nationality, diploma or certificate candidate and age, as well as participation and performance measures in science and math courses can be found in these data. School factors, such as location, percent host culture, private or public, and single-gender or coeducational, as well as size and age of the program can be derived using this school data. Other forms of data for analysis were are collected from various sources. The IBO has only four administrative regions so the UN regions are included as a way to delineate national factors more explicitly. A list of these regions is found in the Appendix F, Table 1.

Description of IB math and science courses. There are five IB STEM subjects, biology, chemistry, physics, mathematics, computer science, which were used in this study. Environmental Systems data was not used as the curriculum went through a major change in 2008 and many schools do not offer this course. Design Technology was also not used because most schools do not offer these courses and their addition might have skewed the data. Both Environmental Systems and Design Technology are offered as standard level courses only. Only data from mathematics and the basic science courses (biology, chemistry and physics) were used in order to keep the data set as focused, yet robust as possible. Diploma students are required to take at least one *Group 4* test in science. This test can be taken at either the standard or higher level. The students are also required to take one *Group 5* subject in mathematics Math Studies, Math Standard Level, or Math Higher Level. Students may take an additional science course for their *Group 6*, or Arts, requirement. Or, a student may choose to take a course as a certificate only. These additional courses do not count toward their diploma but are visible to universities on the student transcript. Taking additional courses is often the case for those students interested in being more prepared in the sciences for university courses.

Description of standard level and higher level courses. "Standard level courses require rigorous study leading to a breadth of knowledge; higher level courses require intensive study leading to mastery" (IBO, Recognition Brochure, p 4). The standard level (SL) courses require 150 hours of instruction. In order to earn an IB diploma, students must take three courses at the higher level (HL). These courses require 240 teaching hours and allow for topics to be studied in greater depth. Again, participation is required for a diploma; not all students taking exams however are diploma candidates.

Preparation of the IBO data. Completion of IB exams (and internal assessment) taken by a student is the definition of participation for this study. The data for school, participant and country were received from the IBO in different Excel files for both Math and Science for each year. Data had to be merged into one data set in order to be placed into the software program, Statistics Package for Social Sciences (SPSS), for analysis. The original data set for science consisted of approximately 85,000 records and the final data set consists of 34,989 students. The US population was not of interest in this study because the focus was international students. The UN Region of North

America includes the US and Canada. Over half of the students taking IB exams live in the United States and Canada. Students were also eliminated from the study if they were enrolled in schools in countries whose number of participants was less than twenty-five, as this might skew the data. Candidates who had not completed the exams (and therefore earned N's or P's) were deleted, as it was unclear why they had not finished an exam. These were also not significant in number. Candidates who took only Design Technology, Computer Science and/or Environmental Science were removed; this involved nearly one-thousand students. Duplicate data was removed. In this instance, the same student retook an exam. Students who took a test twice, once at standard and then at higher level, were counted once at their highest level; this way each candidate is counted only once per subject. Data came primarily from the 2010 school year. The only students in 2009 included in the study were those who also took exams in 2010, so this did not affect the sample size. This study was not meant to analyze the amount of time needed for participation. Standard level courses may be taken the first year. A school may offer Math Studies in the 11th grade year to candidates, so they would then be taking course related IB exams potentially in 11th grade.

Some data had to be manipulated in order to prepare factors of interest. For instance, the percent host culture had to be calculated for each school, as this data is not collected by the IBO. This was done by dividing the number of students of each nationality by the total number of participants in this school. The number of candidates was calculated. Also, the age of the program was calculated by using the starting date of the program given in the data. As mentioned, the UN regions were used as a way to sort by culture. The students' passport data was provided by the IBO. These were correlated to the UN regions. After total preparation, there were 34,989 students remaining in the data set.

Description of extent of participation in mathematics and science. The extent of participation in math and science must be defined. For extent of science participation, two factors will be used: the number of science courses and the "level" of participation (higher level or standard level). Descriptions of the extent of participation can be found in Tables 3.1 and 3.2. The reason for the one-to-six rating was to analyze the extent of participation and to keep the minimum and maximum value for science and mathematics participation uniform. The rating is not meant to imply that the difficulty of a higher level courses is twice that of a standard level course. The rating is used for comparison purposes only. The reasoning is straightforward; students who take more classes are participating more fully. Students who take more difficult classes are required to complete more hours of class time and lab work, as well as complete a broader and deeper curriculum. The level of difficulty does not include the type of science subject (biology, chemistry or physics). The same reasoning applies to mathematics. The difficulty of Math Studies, Standard and Higher Level Mathematics courses is not a linear concept. But, Math Studies would be considered an easier course than Math Standard and likewise, Math Standard Level would be considered an easier course than Math Higher Level.

Table 3.1

Description of the Extent of Participation in Science

Level of Difficulty		Standard Level (1)	Standard and Higher Level	Higher Level (2)
Number of Subjects	*1*	1	x	2
	2	2	3	4
	3	3	4 (2 SL/1HL) or 5 (2HL/1SL)	6

Table 3.2

Description of Extent of Participation in Mathematics

Level of Difficulty	Studies Level	Standard Level	Higher Level
Difficulty Level of Subjects	2	4	6

Analysis of IBO data. The purpose of this study is to analyze factors that affect student participation in math and science. There were eight factors available for this study. Five factors are categorical and three are numerical. These involve both individual and school factors. The two individual factors include gender and region. School factors include the region, size of the program (number of candidates), percent of host country students in the school, legal status (private or public), coeducational status (all-male, all-female and coeducational) and the age of the program.

Data were explored using descriptive statistics to find means, ranges, level of skewness and standard deviation. The analysis of categorical variables was then done using the Chi-Square test. The Chi Square test was set to $p < .05$ where the null hypothesis can be rejected and a relationship between the two variables can be shown. Cramer's V was used to measure strength of association. Briefly, to interpret Cramer's V, a value above 0.10 is weak but acceptable; a value above 0.20 can be considered a moderate and acceptable finding. Anything below 0.10 is considered not generally useful. (See the Cramer's V Interpretation of Strength of Association in Appendix G). This does depend, however, on the number of levels of the categorical variables, so interpretation of this statistic is not necessarily straight-forward, and other interpretations do exist. For use in this study, the V statistic is compared among variables as an indication of relative strength of association. The numerical variables can be analyzed using the One-Way ANOVA. This is appropriate for ordinal variables if the numerical factor is used as the dependent variable. Eta-squared was used to test effect size. In order to better interpret the variable, however, it was necessary to look at the levels for any significant differences. This was done using the Bonferroni test of association. This allowed the comparison of means of each level of participation, so more detail could be seen.

Data Set 2: AIS Statistical Data

Collection of American International School (AIS) data. Many factors may influence career self-efficacy and therefore participation and performance according to the SCCT model. The traits are one aspect but developmental factors are equally important. A deeper understanding of home, school and social life would potentially better explain why students make the choices that they do.

A data sharing agreement was obtained from the high school principal and the researcher worked with personnel within the Admissions Office and Counseling Center to secure the data. This data set includes three years of school data from 2008 until 2010 from the school's databases and from forms found in the counseling office with information on 2010 seniors only. The Admissions Office data contains gender, nationality, parent occupation and education. The Counseling Center's database holds information concerning factors such as prior math background (PSAT data) and current academic performance (GPA). Data concerning expected career decisions were collected from student forms in the counseling office; these data were collected the previous fall for career counseling purposes and updated throughout the year if changes were made.

Preparation of AIS data. The three sets of data from the Admissions Office, Counseling Center and from the student forms were compiled into an Excel spreadsheet for import into SPSS. Career interest data was only available for 2010, but was used in conjunction with the interview data.

Analysis of AIS data. AIS data of 2008 to 2010 represents a population of students taking the IB exams. This is a sample within the school since not all students take the IB exams. Data were explored with descriptive statistics to find means, ranges, level of skewness and standard deviation, similar to the IB population data. Extent of participation was calculated in the same way and similar statistics can be used. Chi Square analyses of the categorical variables and One-Way ANOVA of the numerical variables, as well as Bonferroni tests (comparison of means), were carried out.

Data Set 3: Semi Structured Interviews

Data collection for semi-structured interviews. Data concerning the influence of significant others on both academic choice and career decisions were collected through semi-structured interviews with twenty-four students in the 2011 senior class. Students were eighteen years of age and had to be participating in a math and science course in order to take part in the interviews. Of the seventy students in the senior class fifty-four were IB students and forty-five were eighteen years of age. Twenty-six students volunteered and twenty-four were interviewed. Four samples did not record properly so had to be discarded. Structured interview questions focused on the influence of significant others for student participation in IB math and science subjects, as well questions concerning self-efficacy in terms of future career decisions (Appendix C). As part of the interview, students were asked to rank the influence of significant others (parents, peers, others, teachers and counselors) in their high school academic choices and college and future career choice.

The interviews took place during the three week IB examination period, from May 2 through May 24th. Interviews were taped digitally onto a laptop and then transcribed. Students received a four Euro coupon to be used at the student café after the interview process. All interviews lasted between thirty and forty-five minutes.

Preparation and analysis for data set 3: Semi-structured interviews. Of the twenty interviews completed, eight were male and twelve were female. According to Greg Guest, data saturation occurs after about twelve interviews, which means patterns become apparent (Guest, Bunce, & Johnson, 2006). Interviews were transcribed and patterns were coded. Repeated themes in the dialogue were highlighted by color coding and organized into tabular form if possible. All quantitative questions were tallied onto an Excel spreadsheet.

Summary of Methods

Tables 3.3 and 3.4 outline the research questions and methods used in this study. Due to the ordinal nature of the participation variable, the numerical variable is considered the dependent variable when using the One-Way ANOVA test. Cramer's V tests were used for strengths of association with the Chi-square analyses and eta-squared tests were used in concert with the one-way ANOVA in order to test effect size. Bonferroni tests were also used to gather more information on trends seen within the numerical variables as an attempt to examine differences between the various levels of participation.

Table 3.3

Data Set 1: IBO Data Research Questions and Variables

Research Question	Independent Variable	Dependent Variable	Statistic
1.1 Overview	All Variables	Extent of Participation	%, Mean, Range, SD, Skewness
2.1 Does gender affect the extent of participation?	Gender	Extent of Participation	Chi Square
2.2 Does individual region affect the extent of participation?	Region	Extent of Participation	Chi Square
2.3 Does coeducational status affect the extent of participation?	Coeducational Status	Extent of Participation	Chi Square
2.4 Does public or private (legal status) affect the extent of participation?	Public vs. Private	Extent of Participation	Chi Square
2.4 Does % host culture in a school affect the extent of participation?	Extent of Participation	% Host Culture	One-Way ANOVA
2.5 Does number of candidates (size of the program) in a school affect the extent of participation?	Extent of Participation	Size of Program	One-Way ANOVA
2.6 Does the age of the program affect the extent of participation?	Extent of Participation	Age of Program	One-Way ANOVA
2.7 Does the region of the school affect the extent of participation?	Extent of Participation	School Region	One-Way ANOVA
3.1 Does the level of math participation affect the extent of science participation?	Math Participation	Science Participation	One-Way ANOVA

Table 3.4

Data Set 2: AIS Data Research Questions and Variables

Research Question	Independent Variable	Dependent Variable	Statistic
2.7 How does parent occupation affect the extent of participation?	Parent Occupation (STEM or Not STEM related)	Extent of Participation	Chi Square
2.8 Does gender affect extent of participation?	Gender	Extent of Participation	Chi Square
2.9 Does nationality affect extent of participation?	Nationality	Extent of Participation	Chi Square
2.10 How is extent of participation related to the prior math ability?	Extent of Participation	Prior Math (PSAT)	One-Way ANOVA
2.11 How is extent of participation related to GPA?	Extent of Participation	GPA	One-Way ANOVA

CHAPTER 4: RESULTS

International Baccalaureate World Data Analysis

The first data set contains both individual and environmental or context factors. The individual factors available from this data set are gender and individual or home region. Other individual factors such as socioeconomic status, parent occupation, prior math experience and general student achievement (GPA), are not known for this sample. According Lent's Social Cognitive Career Theory (SCCT), the individual interacts with the environment in order to make choices. School factors which could be attained from the data set include school region, coeducational status, legal status, percent host culture, age and program size as measured by the number of candidates. Besides the schools from the US and Canada, data from regions with fewer than twenty students were eliminated (Polynesia, Micronesia, Melanesia and the Caribbean), though these students may appear in other schools in the world. Therefore, the number of individual regions does exceed the number of school regions. Ultimately, there are two individual factors and seven school factors in this data set. The two dependent variables are the extent of science participation and the extent of math participation.

Descriptive Statistics. An assumption of normality can be met by looking at the overall participation in math and overall participation in science, but the nature of these variables are ordinal and equal variance cannot be assumed. Further the distribution of each of the numerical variables is also not perfectly normal. Distributions of all numerical variables can be seen in Appendix D. Because of the ordinal nature of these dependent variables and non-normal metrics of most numerical variables, this study is non-parametric in design.

A look at the distribution (Figure 2) shows that mathematics shows a slightly different distribution which is due in part to the difference in describing the participation. Mathematics has three distinct courses and students completing the IB diploma must take one of them. Science is more complex. There are three science subjects included in the study - physics, chemistry and biology. Each science subject has two levels of difficulty and a student may take more than one science course.

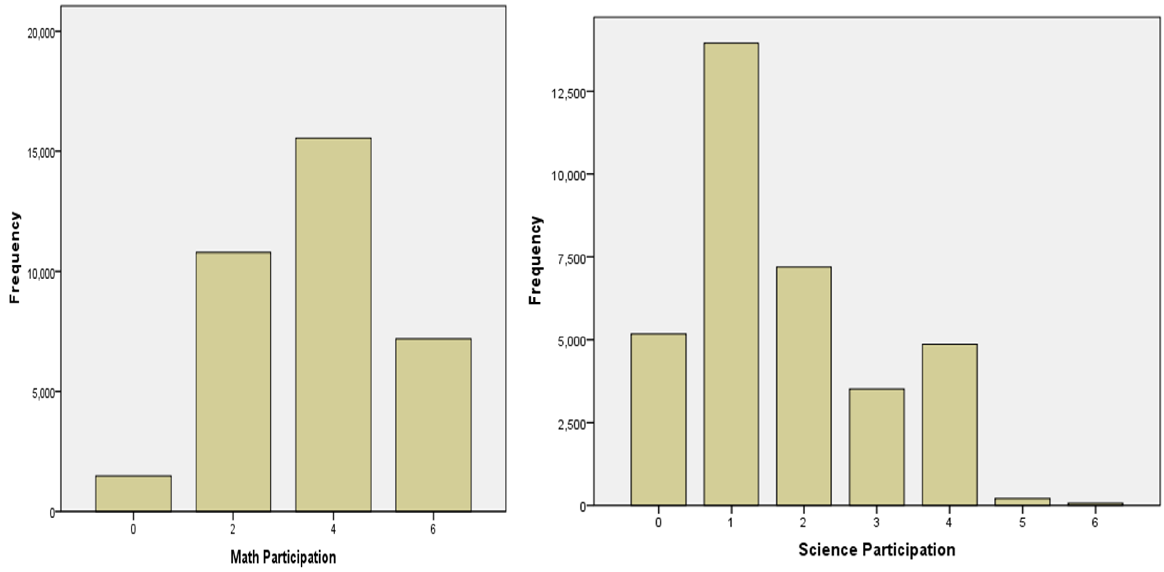


Figure 2: Participation in Math and Science from IBO Data

The same range of participation was maintained for science and math for ease of comparison. Though not identical, both are held to a six point scale. Overall this does not matter, as the subjects are considered separately, except when considering the last research question which looks at the relationship between science and math participation. A level two for math represents Math Studies (the lowest level course possible in math) and a level one for Science represents Standard Level (the lowest level course possible in science). A score of four for math participation represents Standard Level and a two for science represents Higher Level (HL) or two Standard Level (SL) courses. A six in mathematics indicates the participation in the Higher Level Math course and a six in science represents a student participation in three higher level courses. Science contains more possible combinations of course selection but the standard level course is the lowest level. Math has fewer possibilities including one lower than Math Standard Level, Math Studies. The median is the Standard Level for both math and science participation. A look at the descriptive statistics confirms that a non-parametric approach is advisable. Overall students take math more than science.

Data show (Table 4.1) that students take more than one Standard Level science (1.7) and slightly less than Standard Level math (4.0 on this scale). The median is just at the Standard Level for both and the standard deviation is lower for science. Also, the skewness is negative in math and positive in science due to the larger number of possible (though rarer) combinations above the SL in science and due to the possibility of a lower level in math.

Table 4.1

DESCRIPTIVE STATISTICS FOR MATH AND SCIENCE PARTICIPATION
(n = 34989)

Variable	Mean	Median	Std. Dev	Skewness/Kurtosis
Math participation	3.63	4.00	1.61	-.14/-.62
Science participation	1.71	1.00	1.28	.65/-.48

Note: Participating in Standard Level Math has a value of 4 and participating on one standard level science exam is equivalent to a value of 1.

A frequency of students by region is found in the Appendix E. Schools in North America were not studied so were removed. The North American UN region includes the US and Canada. Schools in the Caribbean, Polynesia, Micronesia and Melanesia were also removed because they were in such small numbers that they might skew the data. The final number of students within this sample numbered 34, 989. (One thousand and fifty five students were missing nationalities in the dataset). The largest numbers of students are from South America and Northern Europe.

Descriptive statistics (Table 4.2) shows that the average age of the school was sixteen years, the average percent host culture for the schools was sixty-one percent and the average number of candidates was seventy-one. The strong positive skewness show that the IBO has added many schools in recent years.

Table 4.2

DESCRIPTIVE STATISTICS FOR NUMERICAL VARIABLES
(n = 34989)

Variable (min, max)	Mean	Std. Dev	Variance	Skewness/Kurtosis	Range
Age of Program	16.0	10.00	99.76	.71/-.47	39 (3 - 41)
% Host Culture	.6	.34	0.33	-.39/-1.35	1 (0 - 1)
Number of Candidates	71.0	69.96	4893.81	2.82/10.18	440 (1, 441)

The broad range for percent host culture shows a fairly flat curve with a few schools with one-hundred percent host cultures. IB schools tend to have small student populations though there are a few outliers. The size of the program has been determined by the number of candidates; this should not be confused with the size of the school. Distributions can be found in Appendix D. Some schools had data missing for coeducational and legal status.

Table 4.3 shows that the total sample consists of slightly more girls than boys. Approximately fifty-two percent of the sample is girls and forty-eight percent is boys and most schools are coeducational in nature. At least eighty-eight percent of the students attend coeducational schools, four percent attend all-boy schools and two and a half percent attend all girl schools. Some schools did not declare this status. Of the sample, eighty percent of the students attend private schools.

Table 4.3

DESCRIPTIVE STATISTICS FOR CATEGORICAL VARIABLES IN MATH PARTICIPATION
(n = 34989)

Variable	n	Mean Math	Std. Dev	Variance	Skewness/Kurtosis	Cramer's V
Gender						
Female	18193	3.45	1.54	2.37	-.04/-.50	0.14
Male	16796	3.81	1.66	2.76	-.30/-.66	
Coed Status						
Coed	30921	3.64	1.60	2.55	.12/-.63	0.06
Male	1358	4.15	1.78	3.14	-.61/-.52	
Female	852	3.54	1.40	1.86	-.10/-.18	
Legal Status						
Private	26457	3.64	1.59	2.52	-.17/-.54	0.08
State	6674	3.75	1.65	2.73	-.04/-.90	

The same table also analyzes the categorical variables in regard to math participation. The mean math participation score for boys is higher than for girls. Males have a slightly wider variance. All-male schools perform better in mathematics than both coeducational schools and all-female schools on average. They also have a wider range of participation and there is a greater degree of negative skewness in this sample. State schools have a higher mean than private schools but also show a slightly wider variance. Cramer's V is an indicator of the strength of association and can show the percent of maximum possible variation. It is developed next with the Chi-Square analysis, but is shown here for ease of comparison. Gender shows moderate association with math.

Table 4.4 outlines the descriptive statistics for the categorical variables in regard to science participation. Females show a slightly lower mean for science participation than males. Again, males have a wider range of participation. Coeducational schools have a slightly lower average in science participation and a narrower range than all-male schools. This is followed more distantly by all-female schools. State schools again out-participate private schools by a significant margin but show a larger variance. Descriptive statistics for the remaining categorical variables of school region and individual region are found in Appendix E.

Table 4.4

DESCRIPTIVE STATISTICS FOR CATEGORICAL VARIABLES IN SCIENCE PARTICIPATION
(n = 34989)

Variable	n	Mean Science	Std. Dev	Variance	Skewness/Kurtosis	Cramer's V
Gender						
Female	18193	1.64	1.25	1.56	.78/-. 21	.09
Male	16796	1.79	1.32	1.74	.02/-.71	
Coed Status						
Coed	30921	1.70	1.28	1.65	.66/-.46	.05
Male	1358	1.81	1.34	1.80	-..39/-1.09	
Female	852	1.73	1.19	1.43	.98/-.15	
Legal Status						
Private	26457	1.63	1.25	1.56	.70/-.35	.15
State	6674	2.03	1.38	1.90	-.40/-.92	

Chi-square results and analysis. From Chi-Square results, it appears that differences observed in the descriptive statistics are all significant though the strengths of associations vary. The strengths of association can be seen in Tables 4.5 and 4.6 using the Cramer's V.

Table 4.5

CHI -SQUARE VALUES FOR CATEGORICAL VARIABLES – MATH PARTICIPATION
(n = 34989)

Independent Variable	Pearson CHI Square	Sig (2 sided)	df	Cramer's V
Gender (F/M)	645.21	.000	3	0.14
Home Region	4915.67	.000	51	0.22
Legal Status (State/Private)	247.03	.000	3	0.08
Coed/Male/Female	269.50	.000	6	0.06
School Region	2998.23	.000	45	0.17

According to the Chi-Square results, home region, school region, gender, legal status and coeducational status, in order of strength of association (V), provide significant influence on the level of math participation (Table 4.5). The largest association is caused from the individual's home region (V = 0.22), followed by the region of the school (V = 0.17) and then gender (V =.15) and legal status (V =.08). Legal and coeducational status are below the minimally acceptable (V =.10) Cramer's V. Since the mean percent host culture for all schools is 61%, we can assume that a significant number of students represented are living in their home country so the variables school region and home region may be influencing one another. The weakest association is seen with coeducational status, even though it is significant. Again, significance here may be attributed to the large sample size.

Table 4.6

CHI -SQUARE VALUES FOR CATEGORICAL VARIABLES –SCIENCE PARTICIPATION
(n = 34989)

Independent Variable	Pearson CHI Square	Asymp. Sig. (2 sided)	df	Cramer's V
Gender (F/M)	278.57	.000	6	0.09
Home Region	5057.90	.000	102	0.16
State/Private	679.73	.000	6	0.14
Coed/Male/Female	190.57	.000	12	0.05
School Region	4643.91	.000	90	0.15

For Science Participation, all categorical variables again show a significant relationship between the independent variables of gender, region, legal status of school, coeducational status and region of school (Table 4.6). The Cramer's V shows that the strength of association varies among the factors. In Science Participation, the home region (a reflection of the nationality) is seen to have the highest effect (V =.16), followed by school region (V =.15), gender (V =.09) and coeducational status (V =.05). Gender and coeducational status are below the minimally acceptable (V =.10) Cramer's V. Gender has a greater effect in math participation (V =.14) than science participation (V =.09). This may be due to the lack of differentiation among the science subjects at this point.

Gender and math participation. Histograms in Figure 3 show that there is a tendency for girls to choose to take Standard Level math, or no IB math at all, more than boys. Taking a closer look at the results of the cross-tab in the Chi –Square concerning gender leads to some deeper findings. Girls do not choose to take HL math at the same rate as boys. Information from cross-tabs indicates that approximately 15% of girls and 26% of boys take Higher Level mathematics. The box plot in Figure 3 also shows that boys have a broader range of participation and make up most of the top-participators in mathematics.

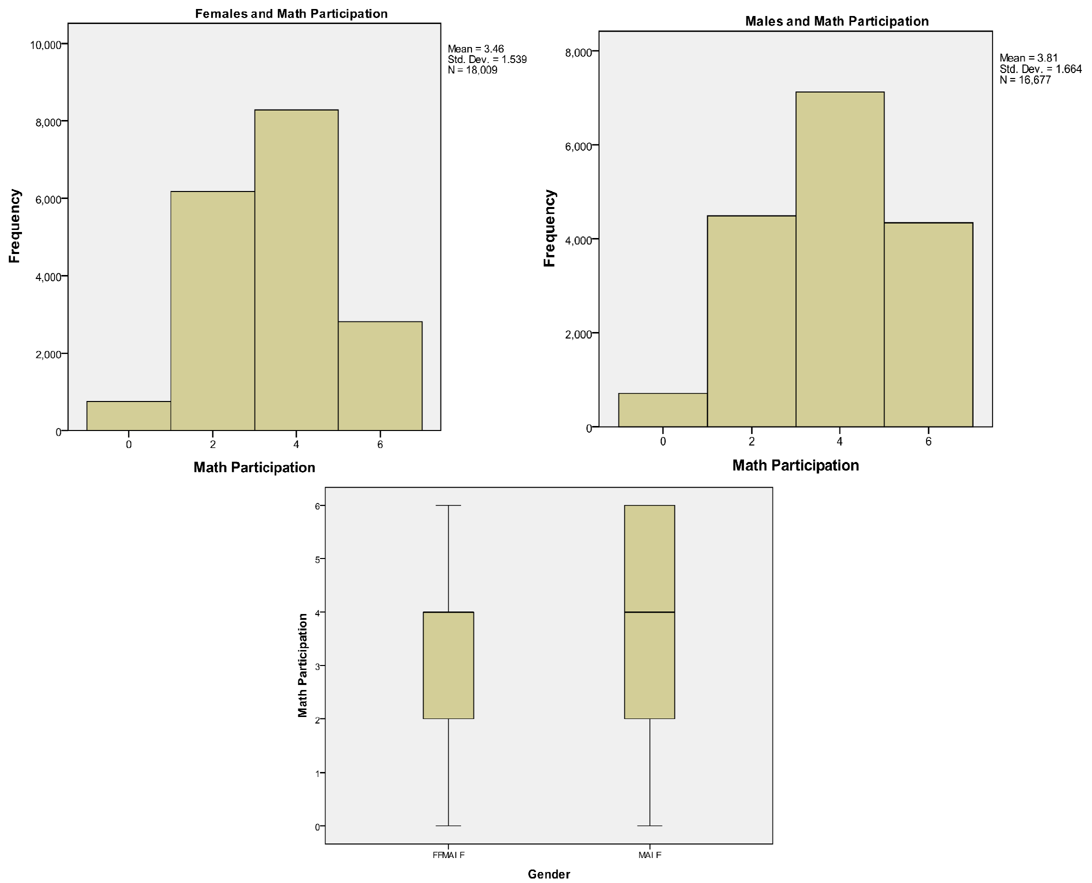


Figure 3: Gender and Math Participation

Gender and science participation. Box plots of gender and science show similar findings. Males outnumber females as top- participators in science (Figure 4). Cross-tab results from the Chi-Square in science shows that six percent more females take Standard Level only and males are slightly more likely to take Higher Level or two or more science classes than females. The strength of association (V) of 0.14 in math and 0.09 in science indicates math is more affected by gender than science.

The small difference between genders in participation may be due to the fact that the science subjects (biology, chemistry and physics) have not been delineated at this point in the study. This will be looked at more closely later.

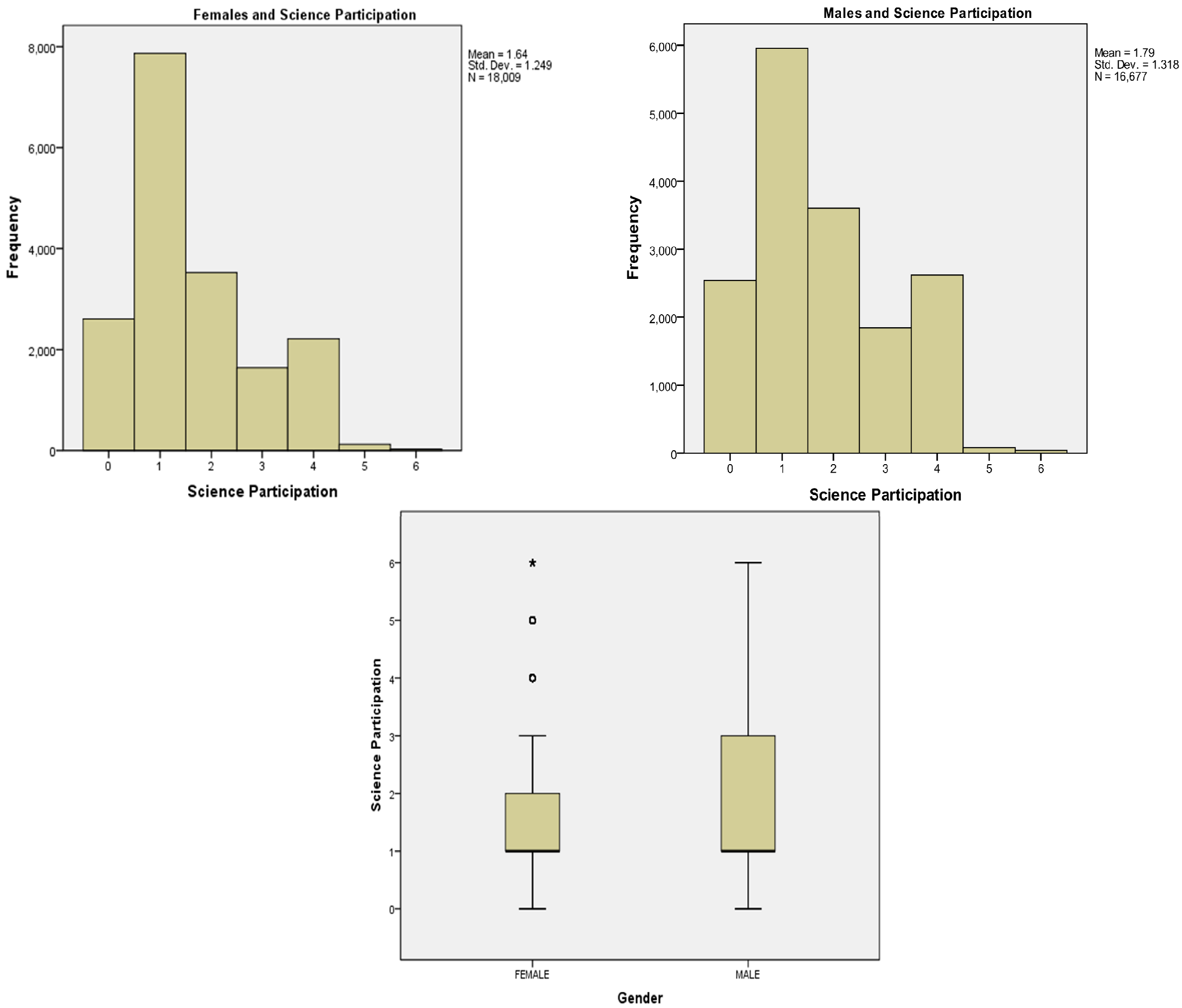


Figure 4: Gender and Science Participation

Individual and school region in math participation. Cross-tabs of Chi Square output show that there are significant differences among the individual regions (Appendix E). Students from East Asia, Eastern Europe, South Central Asia, and

Southeast Asia have the highest rate of math participation. This can be seen by comparing the counts at the highest level with the expected count. Students with low participation scores came from North America and South America where the students who did not participate or who participated in Math Studies, outnumbered the expected count. This trend was also seen in Northern Europe where students taking Math Studies outnumbered the expected count. The box plot is a simpler way to observe the differences (Figure 5).

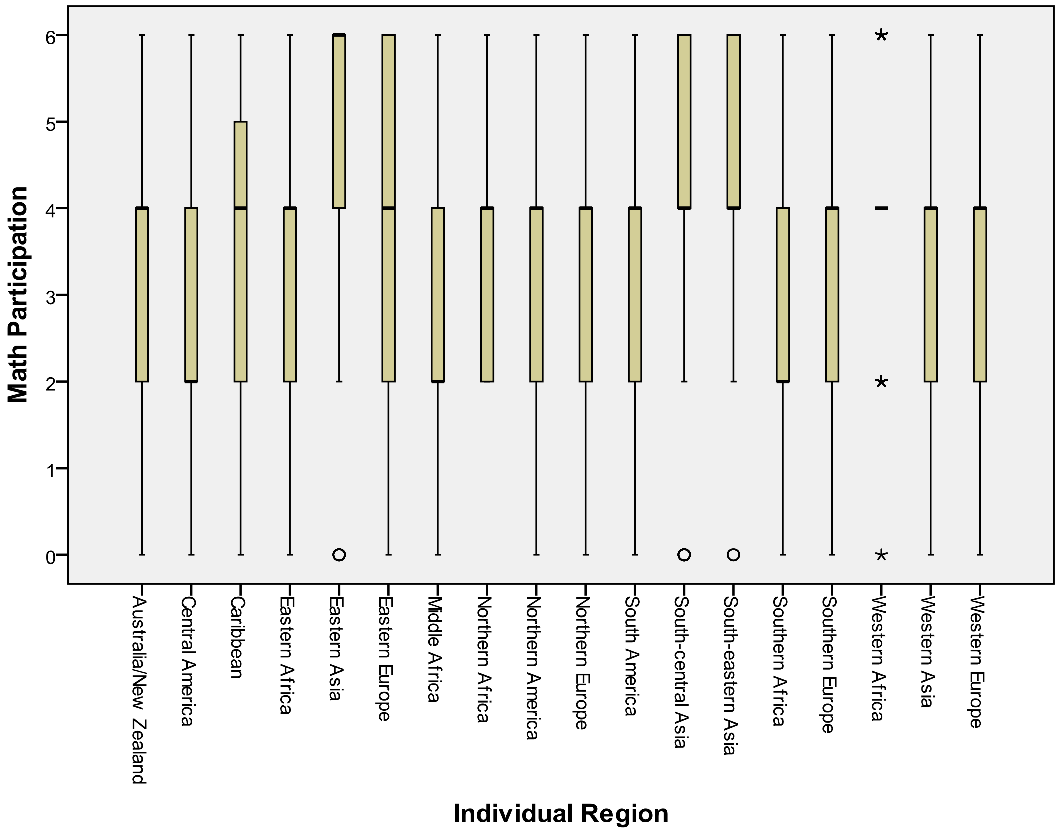


Figure 5: Individual Region and Participation in Mathematics

Students from the three Asian regions show a smaller variance as well as top participation. We can see that several individual regions stand out as top participators.

Students from North America are not among these groups. The school regions seem to mirror the individual's region quite closely except Southern Europe seems to stands out in regard to school region (Figure 6).

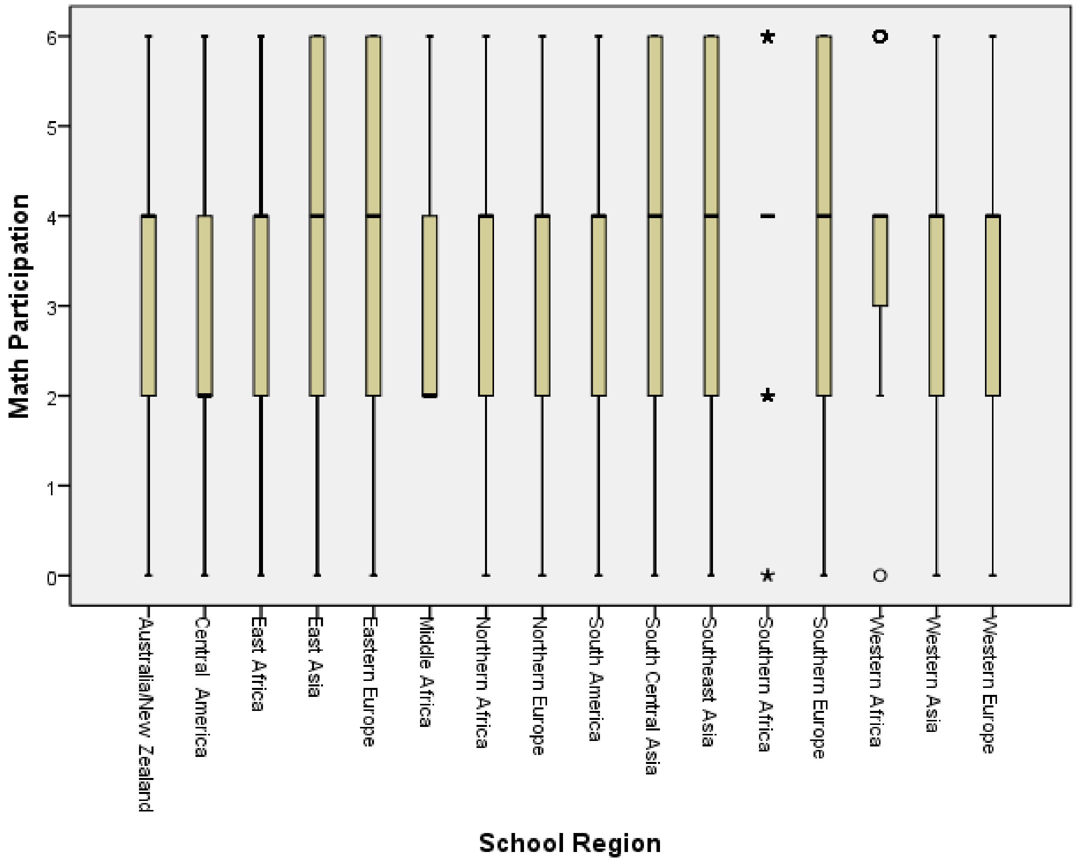


Figure 6: School Region and Participation in Mathematics

Individual and school regional differences in science participation. Individual regional differences with a Chi Square show that top participation rates in science came from South-Central and Western Asia, followed closely by Northern Europe, and, Australia/New Zealand (Figure 7). Cross-tabs show that the actual count significantly outnumbered the expected count. Students from the regions of Central America, East

Asia, Eastern Europe, South America, Western Europe and North America participated less than expected. An apparent emphasis on math participation in Eastern Asia over science participation is evident. School trends show that Southeast and Western Asia as well as East Africa show high levels of participation, followed by Northern Europe and South Central Asia. Schools from Central America, Eastern Europe and South America had lower levels of science participation than expected using the cross-tabs (Figure 8). Frequencies can be found in Appendix E.

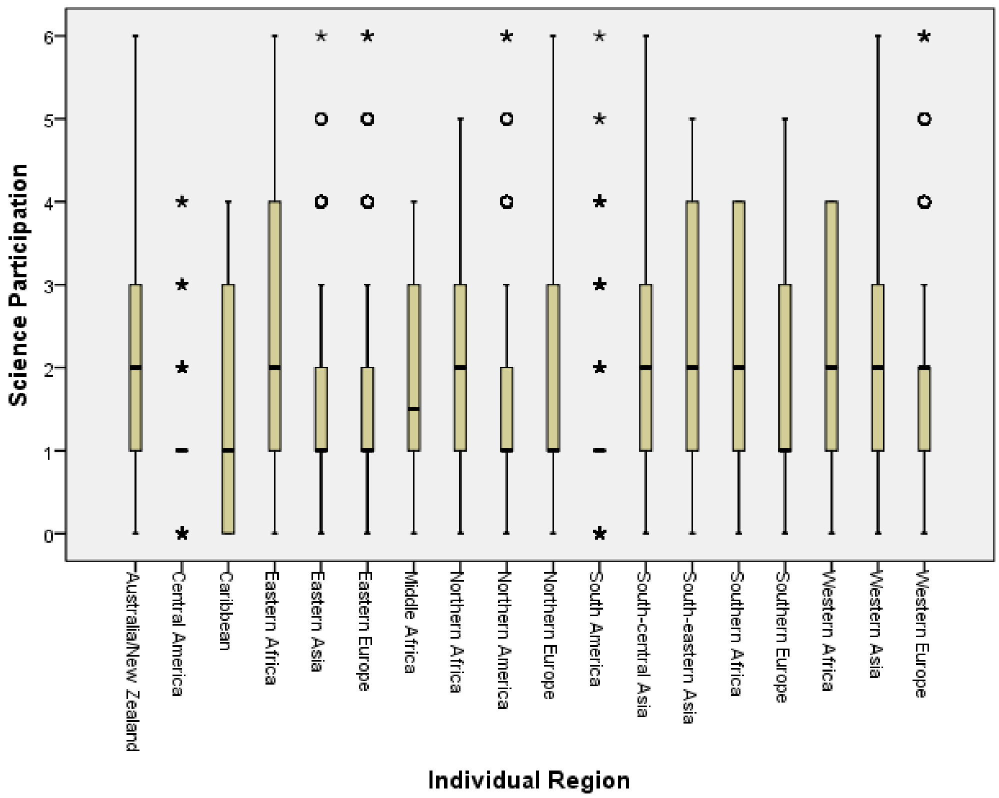


Figure 7: Individual Region and Participation in Science

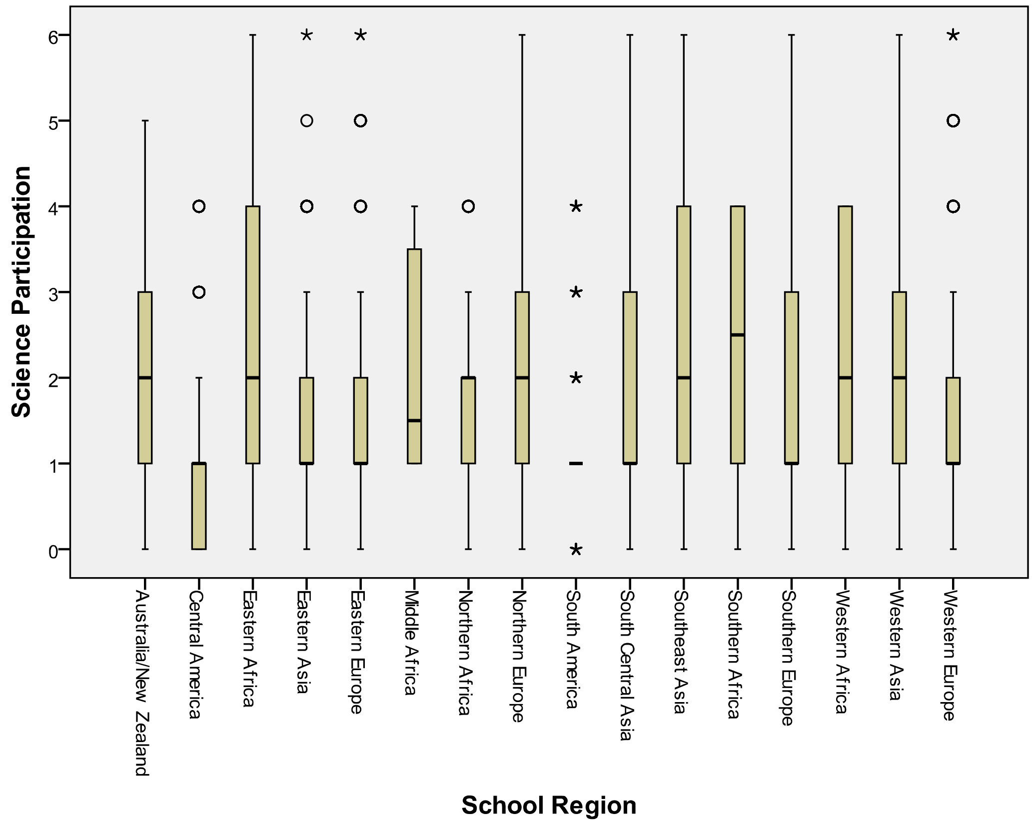


Figure 8: School Region and Participation in Science

Legal status and participation. There is a significant difference between participation rates in state and private schools outside of the United States. Of the nearly 35,000 students in the sample, 6000 attended state schools. Cross-tabs show that private schools had expected counts less than expected for the highest levels (4 - 6) of science participation and higher than expected for the lowest levels of participation (0 - 2). A similar trend is seen in math participation. The legal status of school shows a .08 Cramer's V for math and a .14 Cramer's V for science participation. The status has a greater effect on science participation than on math participation but both are weak associations. Trends are found with the cross-tabs. While the average and the standard deviation are similar, state run schools have a higher percentage of top participators, especially in the area of mathematics. This may be due to the number of students taking the courses for certificates versus the number of students taking the full IB diploma. A closer look at the choices made by diploma versus the certificate student would be interesting. It may also be due to available funding to support higher level courses which require more time and teacher expertise in these areas. It is unclear and more detail is necessary to unravel this difference. With eighty-eight percent of international students in private schools this becomes an important question.

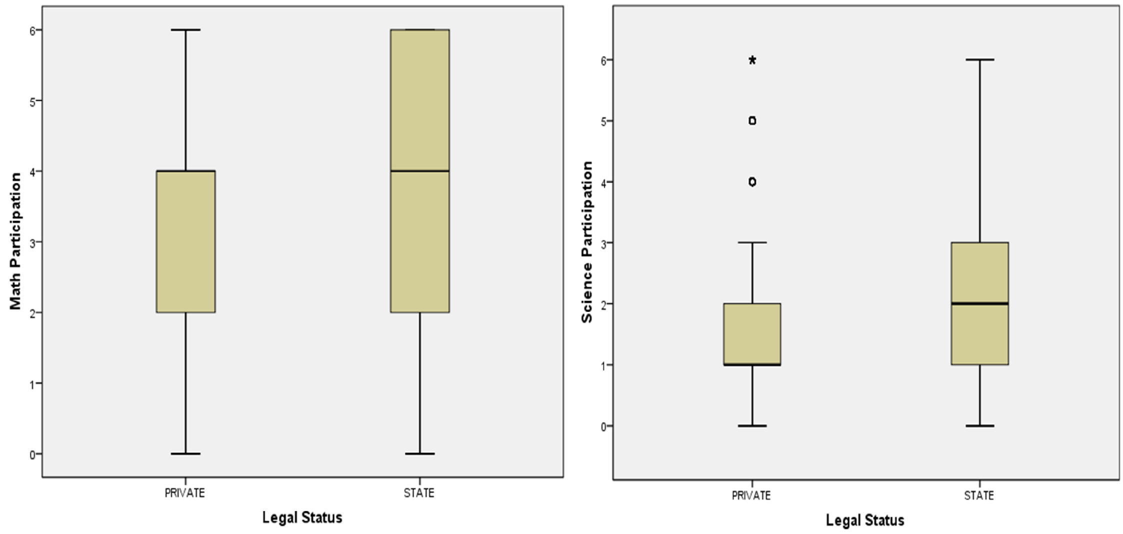


Figure 9: Legal Status and Math and Science Participation

Coeducational status and participation. There is also a significant difference in means between coeducational, female and male schools though the Cramer's V is the smallest for this variable. There may be interactions between this variable and gender as well as school region as some countries such as Australia and New Zealand tend to have more single-gender schools.

Chi - square analysis shows that all-male schools have the highest participation in both math and science. The all-girl schools in this data set do not show a high degree of participation in either math or science. With a closer look at the cross-tabs and box plots (Figure 10), it can be seen that the expected count is almost comparable in coeducational schools, with higher level slightly greater than expected and standard level slightly lower than expected. A look at the gender specific schools with cross tabs allows a comparison of students who take standard level to those that take higher level. It is seen that students in all-girl schools participate less than expected at the higher level and more at the standard level, while students in all-male schools participate more at the higher level than expected and less at the standard level. Further these data indicate that in science and math, the number of top participators (greater than one higher level) in all-female schools is slightly less than expected and the number of top-participators in all- male is more than expected.

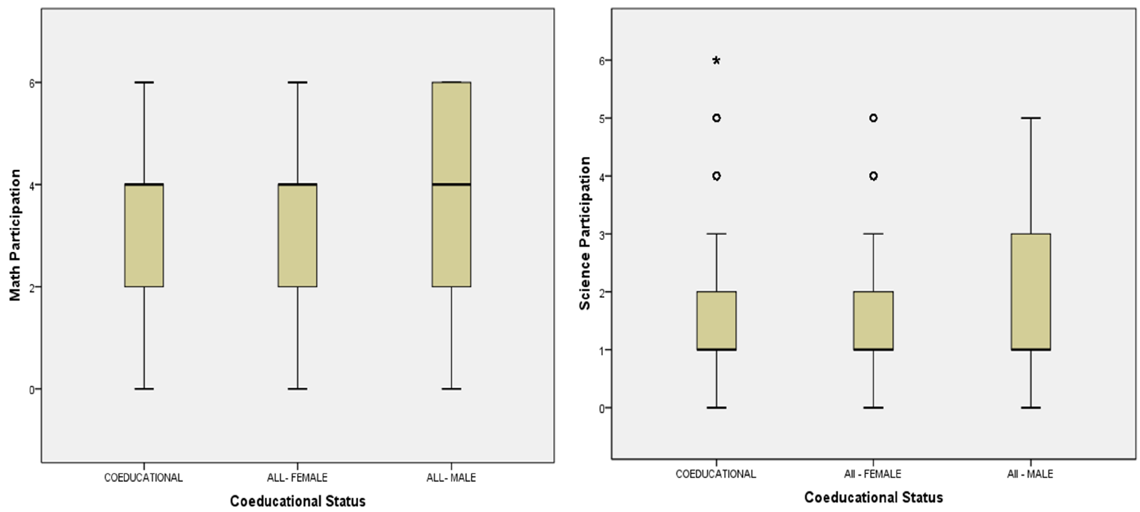


Figure 10: Coeducational Status and Math and Science Participation

The largest number of all-male schools is found in Southeast Asia followed by Northern Europe. The largest number of all-girl schools was found in Australia, New Zealand and South America. There may be some regional influences involved in this outcome.

One-Way ANOVA for Analysis of Numerical Variables

Math participation. Assumptions for this test include equal variance and normality though this test can "withstand robust departures from normality". To use the one-way ANOVA however the extent of participation needed to act as the independent variable due to the ordinal nature of the variable (LeBeau, personal communication, June 25, 2011). Like the cross-tabs, the Bonferroni test of means was also carried out to gather more information about participation categories. This procedure can be used as a way to evaluate the information more deeply as it compares means at the individual levels of participation (Norusis, 2010).

The variables are compared as way to investigate relative differences. The Bonferroni output (Figure 12) shows a negative trend between age of program and math participation. Evaluating the numerical results indicate a positive difference in means between No Participation and all other levels of participation. This means that this category was higher than all others. It therefore also shows as a negative difference of means for the Higher Level to all others levels. This indicates that older schools show a lower level of participation than newer schools. This finding was supported by a significant (at $p < .01$) negative Spearman correlation of .07. The Spearman correlation is a nonparametric statistic. The range of means is slight between within level two through six, but is more dramatic between no-participation and all others. The range there is about six years.

Table 4.7

ONE-WAY ANOVA FOR MATH PARTICIPATION VS. NUMERICAL VARIABLES
($n = 34989$)

Dependent Variable	F	df	Between SS/Total SS	Sig.	η^2
Age of Program	116.91	3	34642 /3490238	.000	.01
% Host Culture	12.96	3	4.465/ 4023.35	.000	.001
N of Candidates	460.13	3	6499481.143/ 1.71 x 10^8	.000	.038

For percent host culture, a negative relationship between participation in the highest level relative to all other levels of participation is seen indicating a tendency to decreased participation at the highest level. No significant comparison can be made between the Math Standard Level and Math Studies courses for this variable however. A significant negative Spearman correlation of .02 was also found for this relationship. The effect size was extremely low (η^2= 0.001) in regard to % host culture and math participation.

The number of candidates seems to have the greatest effect on math participation (η^2= 0.38) among these variables, and Bonferroni tests show some interesting results. The size of the program factor (number of candidates) shows a positive relationship at both the level of no participation and the top participation in math, but a negative relationship in the intermediate levels (as compared to the outer). These results showed an overall positive Spearman correlation of .05. Bonferroni results are displayed in Figure 11.

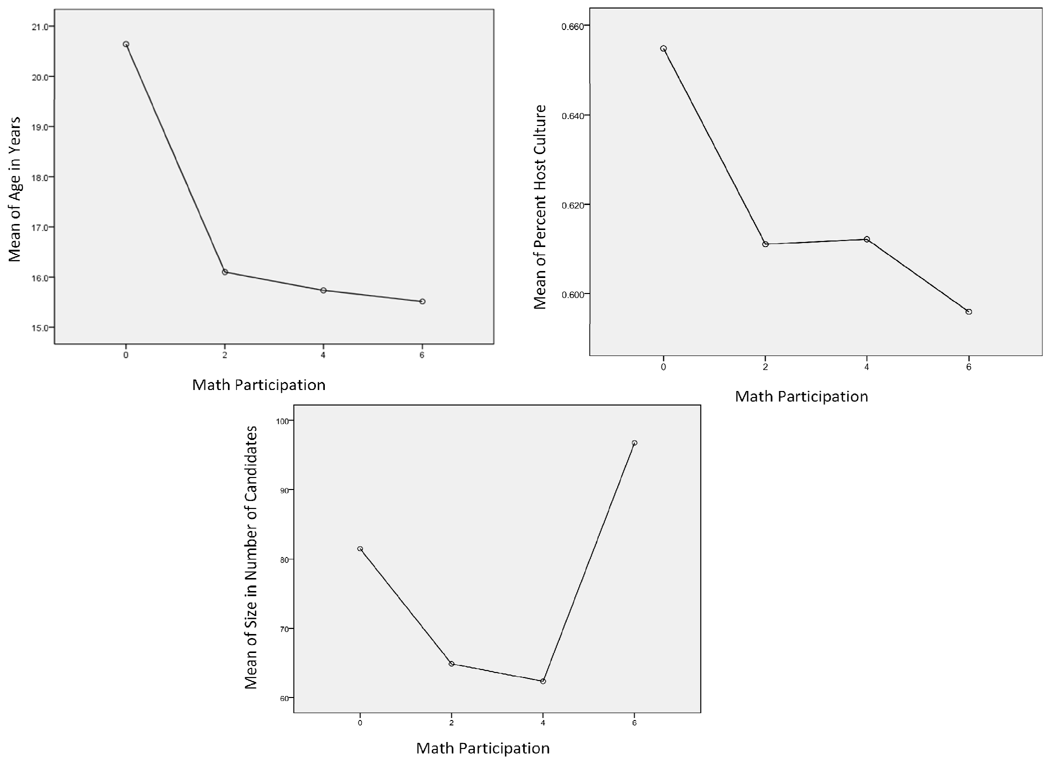


Figure 11: Comparing Means of Numerical Variables in Mathematics Participation

Science participation. Results from the ANOVA show that all effect sizes are small for science participation as well, even though they are significant (Table 4.8). Effect sizes are compared as a way to explore relative importance of variables. The highest eta-squared again is number of candidates followed by the percent host culture and distantly by the age of the program. When looking at Bonferroni results, it should be remembered that a level five and six in science means that the student has taken three science classes. (Bonferroni trends can be found in Figure 12). The IB program allows for two science courses within the program, all other courses would be taken as certificates – so this trend is unlikely for most diploma candidates. A level four implies that the student has taken two courses at the higher level, which is a solid level of science.

Table 4.8

ONE-WAY ANOVA FOR SCIENCE PARTICIPATION VS. NUMERICAL VARIABLES
(n = 34989)

Dependent Variable	F	df	Between SS/Total SS	Sig	η^2
Age of Program	36.56	3	11213. /3490239	.000	.003
% Host Culture	265.81	3	94.1/4023.5	.000	.023
N of Candidates	157.55	3	$4.865x\ 10^6/1.71x10^8$	.000	.030

Bonferroni results indicate however that there is a fairly steady and negative relationship (except for the highest level) between the age of the program and participation in science. This is confirmed with a negative Spearman correlation of .06.

Significant mean comparisons can also be found for percent host culture, but observation of the trend shows no clear relationship. A negative Spearman correlation of

.03 was found. If only comparing the lowest level of participation to the highest, it appears that schools with higher host culture percentages do better in science. It is possible that other factors need to be controlled in order to discern real differences.

The size of the program factor, number of candidates, shows an increase in means between the level of non- participation and level four (or two higher levels), the trend is fairly flat until this point. Means of five and six seem more prominent at schools with small candidate numbers, while those of four (more likely scores for diploma students), occurs in schools that average 100 candidates. The Spearman correlation is significant and positive here (.02) as well, but very low. This lower level of correlation may be due to the erratic nature of the means.

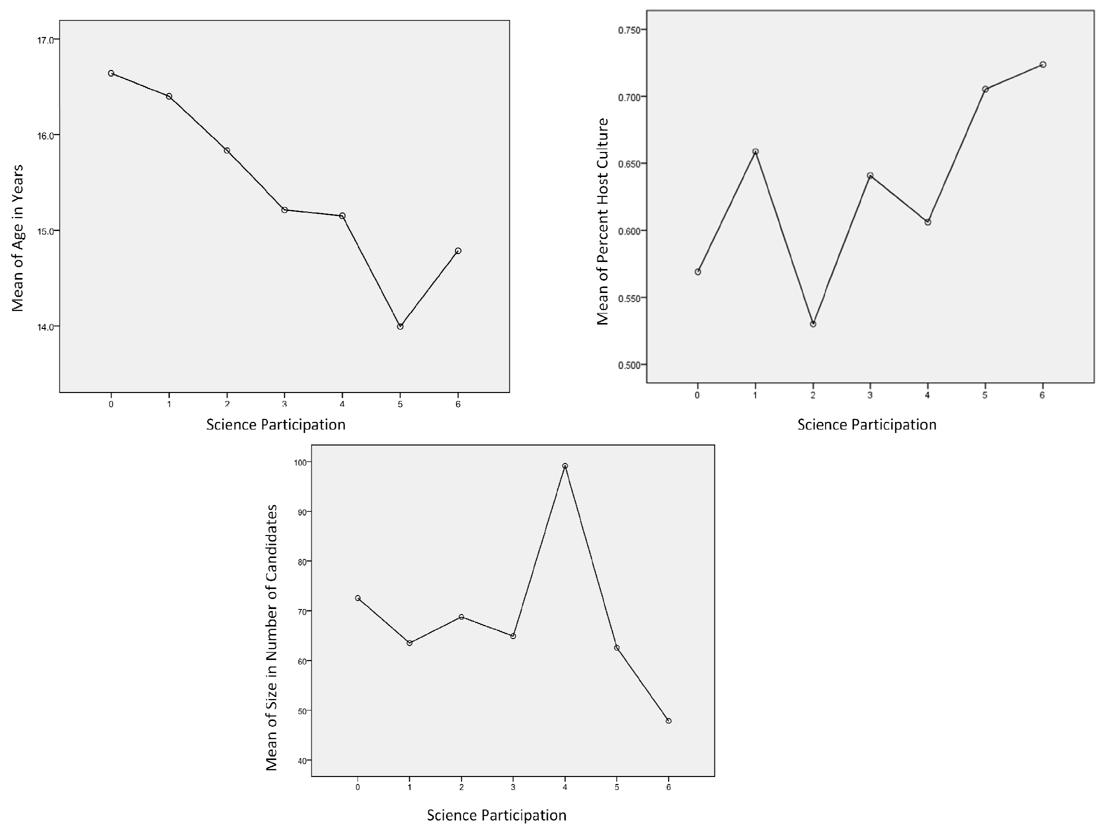


Figure 12: Comparing Means of Numerical Variables in Science Participation

Science Participation – A Closer Look

A Chi-Square analysis (Table 4.9) of the science subjects shows that males are more likely to take physics and females are more likely to take biology. The top-participators in each subject show that nearly two-thirds of the Biology HL students are female and over three-quarters of the Physics HL students are male. The Cramer's V values show that the greatest gender effect is in physics followed by biology, and then chemistry. Cramer's V again shows the strength of association between participation and gender for each subject (Appendix G). A "moderate" (V = .22) of the biology variance is in favor of girls and a "moderately strong" (V = .27) of the physics variance is in favor of boys. Chemistry data show a "very weak" association with a Cramer's (V = .04). Gender and science participation overall shows a significant Chi Square result (Table 4.6) but a "very weak" Cramer's value (V = .09) overall indicates the need to differentiate between the science subjects to get a more accurate understanding of how gender affects science participation.

Table 4.9

TWO-WAY CHI -SQUARE FOR SCIENCE PARTICIPATION

% At Level of Participation / % of Total (0 = No Participation, 1 = SL, 2 = HL)
(n = 34989)

	FEMALE	MALE	Chi-Square	Cramer's V
BIOLOGY PARTICIPATION			1625	.22
0	41 / 20	59 / 29		
1	64 / 17	36 / 10		
2	61 / 15	39 / 9		
CHEMISTRY PARTICIPATION			58.46	.04
0	53 / 35	47 / 31		
1	52 / 7	49 / 7		
2	48 / 9	52 / 10		
PHYSICS PARTICIPATION			2510.3	.27
0	60 / 43	40 / 29		
1	39 / 5	61 / 8		
2	24 / 3	76 /11		

Math as a Factor in Science Participation

The final research question examines the relationship between math participation and science participation. Analysis of the effect of math participation on science was carried out using the Chi-Square and can be seen in Table 4.10. There is a significant relationship between the participation in math and the participation in science. That all students must take science and math to complete the IB diploma explains much of the association, but by looking at the Cramer's V, we see that the strongest association is seen between math participation and physics participation, followed by chemistry participation and lastly, participation in biology. We see that the Cramer's V for biology is less than that for the overall relationship between science and mathematics and that the Cramer's V for physics is greater than that for the overall relationship. The directional eta measures show that the mathematics is more important for science participation in physics but less important in terms of the biology participation. This might be expected as math is more useful in the area of physics, especially at the secondary level.

Table 4.10

CHI -SQUARE VALUES FOR MATH PARTICIPATION AND SCIENCE TYPE
(n = 34989)

	Pearson CHI Square	Cramer's V	df	Asymp. Sig	η^2
OVERALL SCIENCE	7238.19	0.26	18	.000	.43
BIOLOGY	2911.11	0.20	6	.000	.25
CHEMISTRY	4970.07	0.27	6	.000	.36
PHYSICS	7458.81	0.33	6	.000	.43

Descriptive Comparison of Student Choice of Science Subjects

Data from the IBO Statistical Bulletin for the 2010 exams give information about the number of students in each subject by level. These data include all students including the United States and Canada. A simple ratio of the higher level to standard level indicates that students overall are more comfortable with biology with a 1.41:1 ratio, chemistry is comparable with a 0.99:1 ratio and physics has the lowest ratio of higher level to standard level ratio of 0.74:1. Math Standard Level to Mathematics Higher Level has a ratio is 0.46:1. The ratio of HL Physics to HL Mathematics is 0.68:1. Students are less likely to take physics, even those taking mathematics at the higher level. In fact, physics is underrepresented worldwide. A total of 15,785 students took SL and HL Physics, while 36,727 students took SL and HL Mathematics (IBO Statistical Bulletin, 2010). It appears that math is not the only barrier preventing students from taking physics. Some possible explanations might be that physics may be perceived as a tougher course, there may be sex-role associations with the course, or perhaps the course is not being offered in some schools. To look at the difference between international schools and world schools, the higher level to standard level ratios were generated using the data set. It was found that the ratio for biology was 0.92:1, for chemistry was 1.37: 1 and physics was 1.03 to 1. It appears that internationally, students are taking higher level options in chemistry and physics more often than students in the US or Canada. Further research into this area would be useful. Physics is a likely prerequisite for students on an engineering career path.

American International School (AIS) in Western Europe Data Analysis

Descriptive Statistics

The sample represents the students at an international school in Western Europe who participated in IB math or IB science in the last three years, 2008 until the present. Three years of data were taken to increase the sample size and, due to the smaller number of regions, the nationalities were used directly. The AIS is one of the first 100 schools in the world to implement the IB program and is situated in Western Europe. It offers the full IB diploma program. The sample consists of 37 nationalities, though 121 of the 194 students come from three nations: Austria, Korea and USA. Due to the unequal variance here, nationality data should be considered suspect. There are 194 students in the sample 104 girls and 90 boys. The PSAT test is taken by most (but not all) students at the beginning of the eleventh grade year. The PSAT-Math score can be considered a measure of prior math ability which may affect student choice of subjects in both math and science. The grade point average (GPA) is a current measure and is an indication of student achievement. Not all student GPAs were available; eleven GPA scores were not available and it is unclear why this is the case. One important reason for looking at this sample was to investigate two important individual characteristics - prior math ability and student achievement.

Table 4.11

DESCRIPTIVE STATISTICS FOR NUMERICAL VARIABLES for AIS

Variable	n Total	Mean	Std. Dev	Variance	Skewness/Kurtosis
Math Participation	194	2.80	1.96	3.83	.16/-.96
Science Participation	194	1.46	1.42	2.02	.29/-1.3
PSAT Total	165	158.13	26.23	687.80	.31/-.25
PSAT Math	165	55.34	10.34	106.97	.29/-.55
GPA	183	3.27	.60	.36	-.33/-.67

Note: Twelve students did not take Math or Science IB exams so correcting for this the Math Participation average = 3.16 and Science Participation average = 1.67. Both are slightly below world averages of 3.63 and 1.71 respectively.

The descriptive statistics (Table 4.11) of numerical variables show that Math Participation is 2.80 and Science Participation is 1.46. Students are more likely to take Math Studies than Math Standard Level. Students are also more likely to take one standard level science rather than to take a higher level science course. AIS data is based on total number of students graduating rather than taking the exams because the data is available. The world data set also includes students who don't participate in either math or science. Correcting for 'exam participation' AIS Math Participation is 3.16 and Science Participation is found to be 1.65, both are still below world averages. Fifty- eight students took no IB science course and forty-three took no IB math course and twelve students took neither IB math nor science.

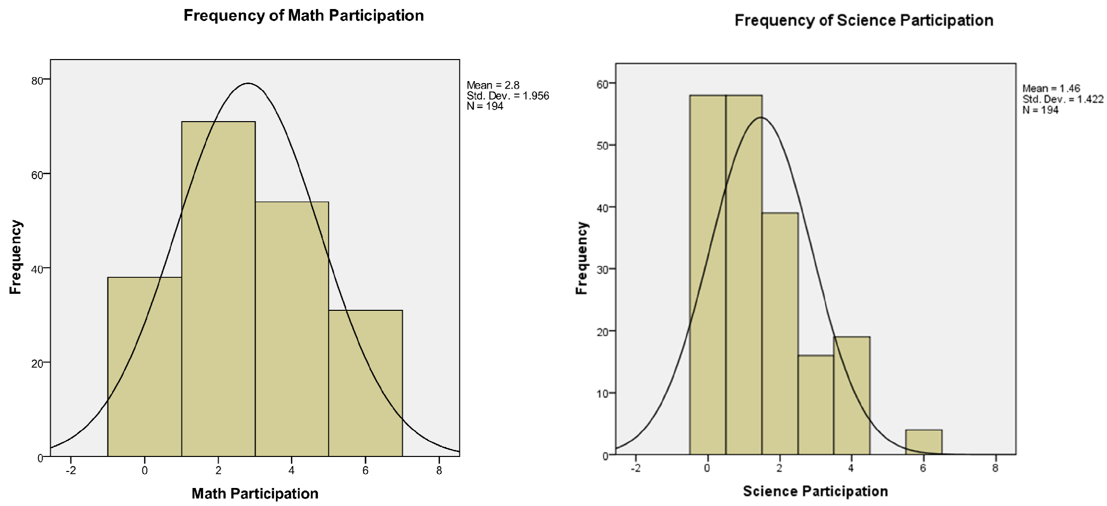


Figure 13: Frequencies of Math and Science Participation at AIS

The other numerical variables are fairly normal in distribution. GPA is skewed slightly to the left, while the PSAT - Math scores are skewed slightly to the right. Histograms of the numerical data can be found in Appendix H.

The distribution of math participation appears to be more "normal" than the distribution for science participation. Again this may be due, in part, to the fact that it is more difficult to attain these higher levels in science, where a six equates to three higher levels. Non-IB math courses, Algebra, Geometry and Advanced Algebra, are offered in preparation for the IB courses. Occasionally AP Statistics is offered, but this did not happen during the 2009 and 2010 school years. A student, therefore, may take these courses and not go on to take IB courses. Many students tend to take more than one science course at a time. Non-IB courses in biology, chemistry and physics are options for students, as well as a year of Introduction to Physical Science. If a student does not complete IB courses, it is fair to infer that they are not taking the most challenging program that the school offers in either subject. As a graduation requirement, students must take three years of math and three years of science at the school and yet may not have taken any IB courses.

Chi – Square Analysis for Categorical Variables

Chi-Square analysis of the categorical variables can be found in Table 4.12. The data show that gender and STEM occupation of a parent are not statistically significant in explaining the participation in math and science. Cross-tabulation in science does show that girls equal boys in number of top performers in science overall, but also tend to have higher than expected count at the standard level while boys have a lower than expected. Cross-tabulation in math is more striking; data show that boys are overrepresented at the higher level and girls are under-represented.

Nationality for math has a Cramer’s V of .44 and for science a Cramer’s V of .45, which is considered “worrisomely strong” (Fletcher, 2006). This may be due to the overrepresentation of three nationalities in the sample. Cramer’s V does indicate that home region is more influential than gender at the school, both had minimally acceptable associations for math and science participation. Findings from this analysis, though not significant, indicate that gender influences math participation more than science participation and STEM occupation of a parent influences science participation more than it does math participation.

Table 4.12

CHI SQUARE VALUES FOR CATEGORICAL VARIABLES – MATH PARTICIPATION
(n =194)

Independent Variable	Pearson CHI Square	Cramer's V	df	Asymp. Sig
Gender (F/M)	5.44	.17	3	.14
STEM Occupation	1.99	.10	3	.58
Nationality	111.94	.44	108	.38

CHI SQUARE VALUES FOR CATEGORICAL VARIABLES – SCIENCE PARTICIPATION
(N =194)

Independent Variable	Pearson CHI Square	Cramer's V	df	Asymp. Sig
Gender (F/M)	3.75	.14	3	.29
STEM Occupation	6.33	.18	3	.10
Nationality	118.06	.45	108	.24

One-Way ANOVA Analysis for Numerical Variables

The numerical variables were analyzed using the one-way ANOVA where the numerical variable is used as the dependent variable and the math and science participation can be analyzed as factors. Bonferroni analysis can be used to investigate the levels of participation more deeply.

PSAT-Total, PSAT-Math and GPA are all appear to be good indicators of participation in both science and math (Table 4.13). The PSAT-Math is possibly the best predictor of math participation and shows a high effect size of .51. PSAT-Math can be considered a measure of prior math ability and GPA a measure of student achievement. All three variables are good indicators of participation in science, but not as strongly associated as they are in math participation. PSAT-Total is an indicator of language ability. It would be interesting to see how language ability affects participation in math and science. The GPA is seen as the weakest indicator for math and the PSAT-Total is seen as the weakest indicator in science. (Figures for these frequencies can be found in Appendix G).

Table 4.13

ONE WAY ANOVA FOR NUMERICAL VARIABLES WITH MATH PARTICIPATION
(n =194) *MATH PARTICIPATION IS THE INDEPENDENT VARIABLE

Dependent Variable	Mean Square	df	F	Sig.	η^2
PSAT-TOTAL	11358.37	3	23.22	.000	.356
PSAT-MATH	2165.22	3	31.56	.000	.505
GPA	5.79	3	17.03	.000	.259

ONE WAY ANOVA FOR NUMERICAL VARIABLES WITH SCIENCE PARTICIPATION
(N =194) *SCIENCE PARTICIPATION IS THE INDEPENDENT VARIABLE

Dependent Variable	Mean Square	df	F	Sig	η^2
PSAT-TOTAL	3217.16	3	5.02	.002	.101
PSAT-MATH	786.89	3	8.36	.000	.144
GPA	2.12	3	6.51	.000	.104

Results from the Bonferroni analysis indicate that all variables show similar trends in explaining mathematics and science participation. In mathematics, there is a direct relationship between the level of participation and these indicators, except at the lowest level of participation (Figure 14). This may indicate that there is a fraction of the student population that is not participating as fully as they might. None of the variables, but especially GPA, appear be a good indicator of participation in mathematics at the level of non-participation.

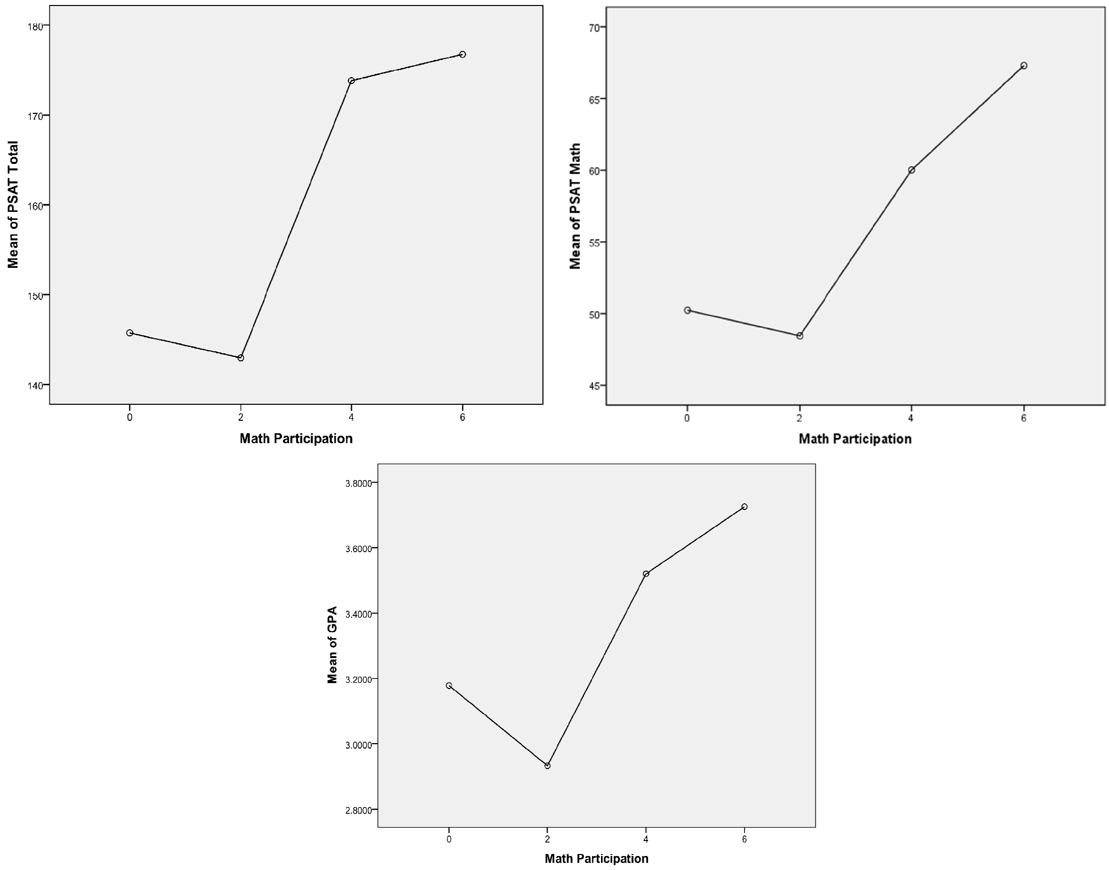


Figure 14: Math Participation and Numerical Variables – Comparing Means

A comparison of means in science also shows similar trends (Figure 15) to one another. The PSAT-Total seems to be a good indicator of participation until the highest level of science (which is nearly impossible to manage due to time constraints for diploma students). This is interesting however as it appears that prior math ability and classroom achievement are not the only factors pushing some students to achieve at the highest level. The PSAT-Math scores mirror the GPA, in general. All variables, except for PSAT-Math, appear to predict whether a student will not participate in science. In a comparison of PSAT-Total to PSAT-Math, math ability does seem to be a prerequisite for a student taking three higher level science courses, but it is evidently not the only one.

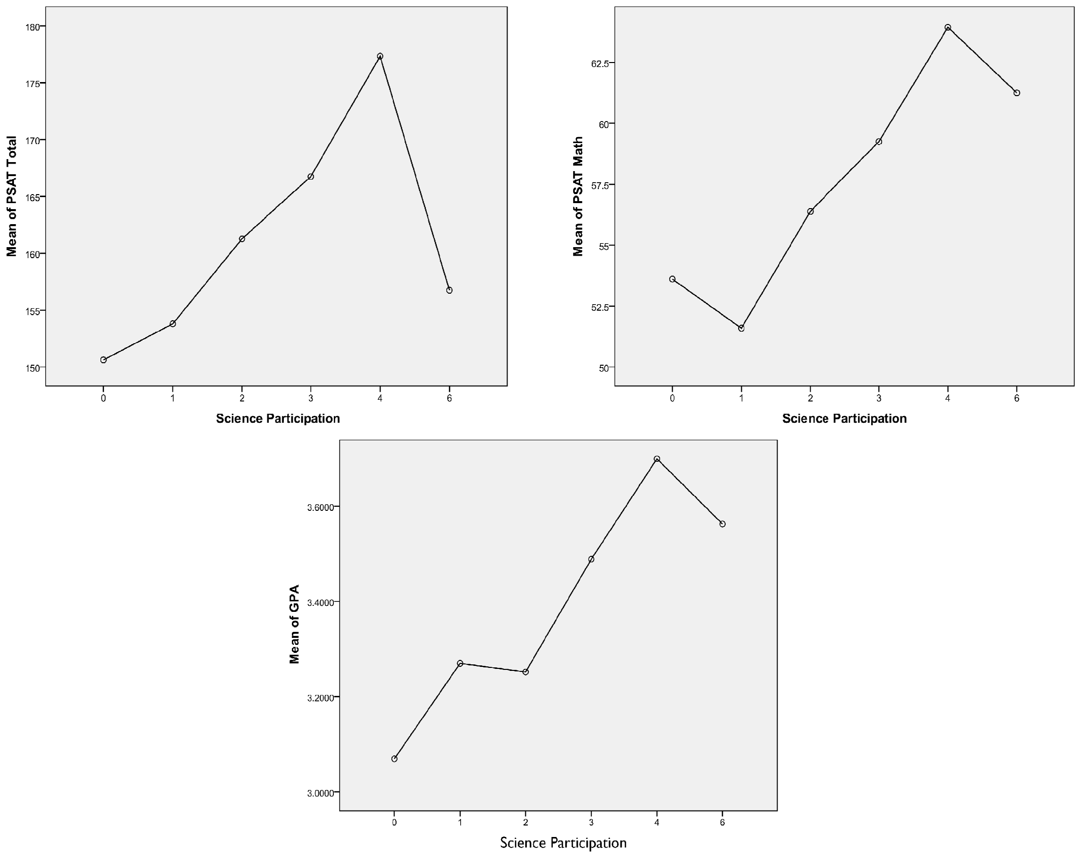


Figure 15: Science Participation and Numerical Variables - Comparing Means

Gender and Numerical Variables

The data show that girls on average have higher GPAs but don't perform as well on the PSAT-Math examination. Boys have a lower GPA and a higher variance. Girls score lower on the PSAT-Math examination and have a slightly higher variance here. Scores on the PSAT-Total are about the same for boys and girls, this implies, perhaps, that girls must be doing better on the language portion of the test than boys. A descriptive analysis of numerical variables by gender is found in Table 4.14.

Table 4.14

Descriptive Statistics for Numerical Variables by Gender
(n = 194)

Variable	Mean	Median	Std. Dev	Variance	Range
PSAT-Math					
Female	53.60	52	10.6	111	44
Male	57.30	57	9.8	95	41
GPA					
Female	3.44	3.48	.526	.277	2.2
Male	3.07	3.04	.613	.376	2.6
PSAT-Total					
Female	157.63	152	27.03	730.78	129
Male	158.71	153	25.41	645.89	119

Science – A Closer Look at AIS

A closer look the number of students in each subject (Table 4.15) shows one reason why the effect size for gender and science participation was not as great as it was for mathematics participation. Looking at overall science ignores some valuable information. At this particular school, we can see that of the 182 students who took IB science exams between 2008 and 2010, 100 were female and 82 were male. Of the females participating 54% took the higher level option and 58% of the boys took the higher level option. This seems comparable. But, when we look at the type of subjects, we find that the girls overwhelmingly participate in biology and boys overwhelmingly participate in physics; chemistry participation is comparable with both genders. Of the 86 students who took biology 71% were female. Of the forty-one students who participated in physics, 71% were male.

Table 4.15

Count of Students in Sciences by Gender
n = 182

	FEMALE	MALE	Total
BIOLOGY PARTICIPATION			
SL	29	14	43
HL	32	11	43
CHEMISTRY PARTICIPATION			
SL	10	11	21
HL	17	17	34
PHYSICS PARTICIPATION			
SL	7	9	16
HL	5	20	25

Note: 136 students participated in IB Science exams, some took more than one.
Therefore 70% of the 194 students participated in IB science courses.

If math is a barrier, for females especially, than it is important to look at the level of math participation at AIS more closely. Data collected within the study show the frequencies of students at each level over the three years (Table 4.16). It is evident from the results that girls are twice as likely to take Math Studies as Math Standard Level. Boys take these courses at equal rates. Only 5% of the girls in the past three years took math at the higher level. Fifty nine percent of the students took either no IB math or no Math Studies. (Students may take two or more sciences so percentages would make little sense in Table 4.15.)

Table 4.16

Count of Students in Math by Gender / % of Total
(n = 194)

	FEMALE / % Total	MALE / % Total	Total Count / %Total
No IB Math Course	32 / 16	11 / 6	43 / 22
MATH STUDIES	40 / 21	31 /16	71 / 37
MATH STANDARD LEVEL	23 / 12	31 / 16	54 / 28
MATH HIGHER LEVEL	9 / 5	17 / 9	26 / 13

Note: 151 students participated in IB Math exams. Therefore 78% of the 194 students participated in IB Math Courses.

Student Interviews

Twenty-four students were interviewed, twelve females and eight males during the IB examination period (four of the interview recordings were not useable so needed to be thrown out). Students were asked a series of quantitative and qualitative questions that can be found in the Appendix C.

Students were asked what they planned to study at university. Nine students intended to follow a STEM academic and career track and eleven students chose non-STEM paths at this point in time. They were asked about what age they were then they had made this decision. Six students were in the eleventh grade, one student was in the twelfth grade, four made the choice in the tenth grade and ninth grade respectively; four were in the middle school and one student said she had chosen her path (architecture) when she was very young. The students were then asked how confident they were about this decision. Students who had chosen this path earlier in high school and middle school were more confident about their decision. On a scale of one to five, all five students who answered with a five were those who decided a career path in ninth grade or younger. Those making academic and career decisions in the eleventh and twelfth graders were less confident, choosing a few more three’s in their answers. Of these seven students, three answered ‘three’ and four answered four to this question.

Students were then asked about the influence of significant others on their current course selection in high school. Students were given cards with the words ‘parents’, ‘teachers’, ‘friends’, ‘counselors’ and ‘others’ written on them. They were asked to sort them in order of influence. Fourteen of the students interviewed, chose ‘parents’ and four chose ‘others’ as the most important influence. Of these four ‘others’, three of these were siblings. The family seems to play an important role in academic decisions, even through high school. ‘Teachers’ were the third and the only other category ranking first for students; only two students chose ‘teachers’ first. ‘Teachers’ were ranked second the most often, with ten, and followed by ‘parents’. The third choice held a tie for friends and counselors.

Students were then asked to resort the cards into an order of who influenced their career choice. Here, parents were still the most influential with twelve students choosing this category. Teachers were the second most likely category followed by others (some of whom were siblings). Counselors and friends were of distant influence for most students in terms of career choice. Students were asked to elaborate on what role these significant others played in decision making. One important theme that came out of this was that parents showed support and interest. Ten students indicated that parents encouraged their interests. One female American student indicated that she looked to her parents as role models. She is currently undecided about her career. She says "Dad is a scientist and Mom is a social worker. Luckily Duke doesn't make me decide right away, as I really don't know yet because I'm getting it from both sides." She obviously is feeling influence from both parents. One Korean boy going into engineering says, "I don't want to let my parents down." Family factors seemed important in this sample. One boy, who will "inherit" his father's business, was influenced by a "sit-down" with a significant other (his uncle) and changed his career path from art to business. Another American male student said that it felt good for friends to "appreciate my performances; it encouraged me along this path. But, my parents were the most influential. Dad asked me what I wanted to do and I said 'theater but it seems ridiculous', and he told me if it is what I wanted to do that I at least needed to try. Then Mom helped me by organizing a summer program. She encouraged my interests and even talked to my teachers about what I could do to be successful." Five other students indicated that their parents provided them with summer study and opportunities to explore their choices. Two students went together to study medicine in India for the summer. One came back "absolutely positive" that this is what she wanted to do. The second decided to change to a business major. Both students were strong students in math and science.

Comments on the influence of friends were minimal, but friends seemed to take on a supportive role. When asked if students talked to each other about what to do next, this did not seem to happen. One boy commented, "Friends just tell you what you want to hear. That's OK, we just want to support each other. We really don't want to talk about what we're going to do as much as where we are going."

Several students indicated that they had good discussions with teachers about areas in which they might excel. Some enjoyed a particular class and made career decisions based on this relationship. It seemed clear that some teachers made an enormous impact on students. The drama teacher in particular played a nurturing role and some of the senior teachers were mentioned more than once. One student said "My middle school science teacher told me that I would make a good doctor. I never forgot that and it encouraged me to keep going with the sciences."

Students tended to have a similar feeling about the role of counselors. "They helped me organize my search by setting deadlines, but I did most of it by myself or with my parents." This again shows a commitment by parents to their child's success and positive family relationships within this sample in general.

Students were asked about how confident they were in their choice and then how confident they were that if they followed this path they would be successful. Students were slightly more confident on average (4.0) that they would be successful than they were in their actual choices (3.85). One student stated, "If I start something I will finish it and will be able to do it." From another student, "I feel that the IB has prepared me well for college, I know I can do anything after finishing this, but I may change my mind in what I want to do." One girl says that though she is not one hundred percent sure in her decision, she has a "stubborn personality" and will finish if she wants to. The reasons given were ranked for frequency. Interest was the number one reason given for the choice given, followed by ability. When asked what barriers they foresaw, students had a few answers. Nearly all answers might be defined as interest or ability. Comments such as "Only myself", "lots of competition", "the idea of politics scares me", "not sure what

I’m facing”, “my ability in German”, “my ability in Math”, “passing the current exams”, “myself – I can be lazy” indicate that students” may feel they don’t have the necessary skills for success. Students were also apprehensive about the future: “they don’t like foreigners in Switzerland”, “living in the States might be difficult”, “luck is a huge factor”. Several students also admitted to possibly losing interest, “I want to like it”, “I may lose interest”, “I may switch to teaching or event planning instead”.

The students interested in a STEM field were slightly more confident. On a scale of 1 to 5, they averaged 4.0 on their academic decisions and just as confident or more (4.1) of their ability to be successful than students in non STEM fields. Whether this translates into staying with it at the university is yet unclear.

Summary of Results

Summary of IBO data set 1. Descriptive statistics indicate that science participation shows a broader range than math participation; the highest frequency of participation is in the Standard Level for both subjects. Overall math participation is skewed to the left and overall science participation is skewed right. This is possibly a result of the fact that math has a course lower than Standard Level and science offers more possibilities above the Standard Level.

Two major individual characteristics, gender and individual region, were investigated relative to school characteristics. The purpose of this approach was to follow the SCCT framework in which the individual’s choices are influenced by his/her surroundings, in this case the school variables.

The Chi-Square analysis was used to investigate the categorical variables. Results indicate that females participate significantly less than males in both math and science but this is more significant in the area of math. Individual regional differences followed by school region have the highest associations followed by gender for math and legal status for science. Individual and school regions showed similar trends. This may be due in part to the host culture influence. Both legal status and coeducational status had a small strength of association. More controlled research, within one country, or a cross-country comparison, would be possible with this type of data set, but will be left for a future investigation. All-male schools do better than both coeducational and all-female schools in encouraging math participation, in that order. All- male schools also do better than all female schools in encouraging science participation. Both do better than coeducational schools. The sample sizes however are small for students in all-girl schools (n = 852) and students in all- boy schools (n = 1358). Also, the location of schools may affect these descriptive results as most all-girl schools were found in Australia and South America and most all-boy schools were found in Asia and Northern Europe. State run schools, on average, do better than private schools in both math and science participation but are especially influential in science participation.

One-Way ANOVA analysis was used to look more closely at the numerical variables: age of program, percent host culture and number of candidates. All numerical variables were significant, though effect sizes were very small. For math participation, the largest effect size was found with number of candidates, followed by age of the program, and lastly, percent host culture. For science participation the size of the program, followed by percent host culture and finally age of the program were significant in decreasing order of effect size. A Bonferroni procedure was applied to each variable. Both math and science participation showed a negative decreasing trend with age of the program. A comparison of means for number of candidates in math shows that higher numbers of candidates are associated with both non-participation and the highest level. This was not as clear in science where a peak (at 100 candidates) was seen at level four, a solid level of participation, but then values dropped with levels five and six showing that means were related to smaller program sizes for these levels. This negative trend seen at these highest levels may be that the sample size is too small to be meaningful. Percent host culture was a more important factor for science participation than it was for math participation however the effect size was small. In math there appears to be a clear decrease with percent host culture and with science the difference between non-participation and level six is positive but any trend is unclear.

Science participation was further analyzed in terms of subject participation. Girls tend to take HL Biology more than boys with a ratio of 61% to 39%. Chemistry participation is nearly equal with boys taking about 4% more HL Chemistry than girls. HL Physics is dominated by males at 76% to females 24%. The Cramer's V here is .27. The relationship between math participation and science participation led to the strongest associations in this data set. A Cramer's V of .33 was found when comparing participation in physics with math participation. The level of math participation showed a "moderately strong" association with biology (V = .20) and chemistry (V = .27). Effect sizes between these two ordinal variables shows a .43 effect size for overall science participation and for physics participation and a decreasing effect (though still strong effect) for both chemistry and biology. Math participation does appear to be a factor in science participation.

Summary of AIS data set 2. The American International School data was used as a way to investigate additional factors including the influence of prior math ability as demonstrated by the PSAT results, student achievement as demonstrated by the GPA, as well as STEM occupation of the parent on math and science participation. No significance was found between participation and the variables of gender, STEM occupation and nationality, though nationality shows the greatest effect size followed by gender and then STEM occupation of parent. The predominance of three nationalities in the school make this result questionable. Gender was associated more closely with math and STEM-occupation of parent with science. The One-Way ANOVA shows a significant relationship of PSAT-Math, PSAT- Total, and GPA with both Math and Science Participation. PSAT – Math was found to be the most important predictor of participation. A look at frequencies shows that girls enrollment out numbers boys enrollment in biology, that chemistry enrollment is nearly symmetrical and that boys outnumber girls decisively in physics. Average PSAT-Math scores show that boys outperform girls on this test even though girls have higher GPAs on average.

Summary of interview data. Student interviews indicate that parents (and siblings) are the most important significant other(s), followed by teachers in both student academic choice of math and science subjects and future career choice. Parents act as role models, but most of the influence is due to guiding their children in the career process through conversations and by giving them opportunities to explore. Teacher-student conversations, as well as student interest in courses, were important but secondary to parent influence. Friends and counselors were not influential in decision-making directly with this group. The barrier most cited was losing interest in math and science.

CHAPTER FIVE: DISCUSSION OF RESULTS

> *"If you move in the direction of your dreams and live the life you imagine, you will meet with unexpected success."* (Henry David Thoreau)

Policy Implications and Further Research from the IBO Data Set

The extent of participation of secondary students in STEM subjects worldwide is a critical issue in education (AAUW, 2010; Weber, 2010; NCES, 2009; Halldorsson, 2009; Murphy, 2006). According to the AAUW, scientists and engineers are needed to solve serious global challenges such as enhanced greenhouse effect, pollution, disease, and energy, food and water shortages. STEM subjects will make up the sixth largest employment sector and lack of available workers is predicted in many high-skilled occupations (Carnevale, 2009). International students are already starting to fill some of the academic and career positions available in the US (Weber, 2010). These students are entering universities around the world and eventually the global workforce. Research concerning student performance in math and science has been carried out in the US as well as internationally with PISA and TIMMS studies, but little research to date can be found concerning math and science participation by students in international schools, including those using the International Baccalaureate program. Data from this research point to policy implications for international schools and a call for more research.

This current study investigated secondary student participation in math and science IB programs in international schools outside of the United States. Results of this study indicate that students tend to take IB science and math at the standard level or at a minimal level of participation. Students involved in the full IB program are required to take at least one math and one science course. The median for participation in math and science is at the standard level; this is perhaps due to students taking more than one science course and Math Studies is an option at the lower level. Thus, it would seem students are taking more sciences, but not necessarily at the higher level. In order to be university and workforce ready, students need to push themselves to take more math and science, and at higher levels. Several factors were investigated within the study. They included both individual and environmental factors. The person is influenced by environmental factors according to the Social Cognitive Career Theory (Lent, 2005). An individual's home region and gender were the two principle individual factors.

Gender, home region and policy implications. Some nations are attaining higher levels of student participation in IB math and science courses more readily; indeed, home region has the greatest strength of association, especially in mathematics. Asian and Eastern European students tend to have greater participation in both math and science; Southeast Asian students show the highest levels of participation in science. East Africa does as well but the sample size is too small at the highest levels to make any generalizations. It would seem important for policy makers in international schools to analyze the educational systems of these nations for insights into possible ways to reform science and math education. Opening dialogue at international educational conferences including IB workshops, administrative conferences or during school exchanges might lead to some enlightening information and sharing of best practices. It would also be important to conduct a similar study by analyzing student participation in IB math and science in schools in the US so that comparisons can be made.

Based on findings, IB schools outside of the US do have a gender divide in the areas of math and science, though mathematics participation shows a bigger gap. Is the

IBO achieving its objective of gender equity? Box plots (Figure 3) for participation by gender show that while the averages are similar for both boys and girls, boys show a larger range of participation and tend to be the top participators in both science and math. That boys out-participate girls is not seen as a remarkable finding as this seems to parallel those findings found in the States; it is, however, important for the IBO and individual schools to know so that this difference might be decreased through promoting more female participation. Else-Quest (2010) remarks that the attention paid to gender gaps has made a difference in the United States performance on the PISA test.

Even without looking at the differences associated with subject type (biology, chemistry or physics) in science, this gap is apparent. Schools, parents, teachers and counselors need to encourage girls to take more risks in terms of science and math participation. In their research, Nagy et al., found that in at least three countries, mathematics self-concept gaps by gender were found; and these researchers deduced that the gaps started before the seventh grade. According to the SCCT choice model, low self-concepts could lead to non-participation. Perhaps dialogue around IB equity standards should begin in elementary and middle school. It would also be interesting to see if starting this process in younger grades would lead to higher participation outcomes. In terms of policy, perhaps the academic counselors and administrators need to better understand models such as the School-to-Work-to-Life model and work toward system changes, as suggested by Solberg (Solberg et al., 2002). Changes must be made at the system level; according to Solberg, working closely with parents and teachers to educate them about the needs of society and career opportunities may be an important start, since they may have greater influence with students. If the IBO's objectives of ethnic and gender equality are incorporated into the school culture perhaps starting earlier is the answer, since most students seem to make career decisions at early ages. Is a narrowing gap found in schools with the middle years (MYP) or primary years programs (PYP)? This would make an interesting study.

One important question might be whether the framework of the IB program allows students to excel in science and math. Future research might look at whether diploma students or certificate students are the best prepared in terms of participation and performance. The IBO forces students to take the higher level courses in their senior year and this may force some to seek standard level opportunities at earlier grades. While the goal of the IBO is a well-rounded student, this may inhibit full participation in some areas, simply due to time pressures.

Coeducational status and policy implications. Results from the remaining research questions indicate possible reasons for these gaps. Coeducational status has been posited as a possible factor that influences participation and performance. In this study, students in all-male schools have a higher extent of participation in both math and science, than students in both coeducational and all-female schools. All-female schools out participate coeducational schools in the terms of science participation. This result was unexpected. Perhaps a study looking at the performance rather than the participation within these schools would lead to a different result. In practice however, girls who do not participate in math or science pose a critical problem, as there is a critical shortage of STEM workers and society needs to increase quantity as well as maintain the quality of females participating. Contrary to other research findings, all-male schools outside of the US using the IB program seem to “push” students more to participate more fully. Case studies in successful all-girl and all-boy schools may lead to greater insight. Coeducational schools do show a very slight advantage over all-girls schools in mathematics. Math seems to be more of a barrier for girls then for boy regardless of setting. Is this because of type of school, school size, region or other factors? Controlling for multiple variables is necessary to answer these questions.

Results were inconclusive for gender-specific schools. Indeed, it seems that boys (not girls) would have more to gain from gender-specific education, but the strength of association was weak. This seems to support the research of Leder and Forgasz (in Bishop, 2007) concerning gender-specific classrooms. Bishop (2007) suggests that "in Australia (and the UK) the distinction between single sex and coeducational schools is interwoven with the division between private and public schooling, which in turn is associated with social class differences" (Bishop & Forgasz, 2007). Harker also found that when SES and prior knowledge were controlled, the differences decreased (Harker, 2000). It is very possible that these variables influence one another. Further research could be extended here to isolate these variables more explicitly. The greater participation of public schools, important in science participation, does undermine the argument that private schools, regardless of coeducational status, offer greater access for either gender.

Practitioners need to discover reasons why girls do not find the coursework interesting or accessible in greater numbers, even in all-girl schools. Curriculum review periods may offer a time to create changes. Recent changes in the curriculum by the IBO to add real-world situations is a start; focusing on solutions to this issue may lead to more concrete changes for students of all nationalities and genders. At the school level, administrators may look at instructional practices and even hiring practices to ensure that teachers understand differences and encourage and support students effectively. One example of schools trying to find out answers comes from Laurel School's Center for Research on Girls in Cleveland. The all- female school has opened its doors to researchers from around the US, including Carol Gilligan (CRG, 2011).

Legal status and policy implications. Students in public (state) schools participate more than students in private schools in the areas of mathematics and science. Public school students in this sample, however, were definitely a minority. Of the nearly 35,000 students, only about 6,000 attended public schools. Results from this study and others indicate that the size of the school impacts participation and therefore possibilities for students. Is it possible that public schools, in general offer a fuller or more complete program? It is also possible that public schools, choosing the IB program, are better endowed than ones that don't offer the program? Is it possible that students in these public IB schools come from higher SES backgrounds, leading to higher participation due to both parental influence and support for higher level courses? The IB is an expensive program. Internationally this finding could be associated with the location of the school because regional variations could lead to differences. Looking at US schools would be interesting because a growing number of public schools in the US are using the IB program, the sample size would be larger there. As noted above, earlier researchers have found that legal status and coeducational status, as well as social class, may influence one another (Harker, 2000). Internationally, what countries are using the IB curriculum in their public systems and why? How are they implementing the program?

Is it a full IB program or certificate courses only? Research into these questions would lead to a better understanding of this finding.

Size of the IB program and policy implications. All numerical variables were again statistically significant, though the effect sizes were small. The statistical significance may be due to the size of the sample. The largest effect size among the numerical variables was for the size of the program, as measured in number of candidates. Research that involves more extensive modeling would help clarify the interactions between the variables. The Bonferroni test looked at the means of each variable relative to the various levels of participation. Bonferroni results for math participation showed an interesting trend. There is a positive difference between means at both the levels of non-participation and highest participation. The greater the size of the program, the greater the tendency toward both non-participation and higher level participation in math. In science larger schools tend to participate at level four or two higher level, but the highest levels of greater than two higher levels shows a decrease. It is perhaps not surprising that the number of candidates is an important factor in participation, especially at these levels of participation. Schools that are too small may not offer the range of program that would appeal or benefit all students. For instance, a school may not offer chemistry or higher level mathematics. Chemistry might be considered an expensive program and teachers in these areas of physics and mathematics may be more difficult to locate and employ. If the school is small there might be a greater need for generalists or teachers who can teach more than one subject, rather than specialists. Alternatively, programs which are too large may suffer more from overcrowded classrooms. This seems to corroborate the UK study carried out by Murphy and Whitelegg (2006), but this should be further researched. The IBO does try to ensure the quality of the programs offered, which is evident by its objectives and standards and program review cycle. It is unclear what consequences the IBO imposes if a broad or rigorous program is not offered. Schools may need to resist the temptation to grow too large without providing the necessary staff and program. Schools that are too small may not be able to provide an adequate program. If students are not taking courses because they are not offered, this presents a serious ethical implication. Parents may need to look closely at IB programs in light of their individual child's future desires to be sure that this is the right school for them.

Age of the program and policy implications. Insights from the ANOVA results and Bonferroni procedures also show that there is a negative relationship between the age of the IB program and participation in both math and science. But, the effect sizes were very small. The range of this comparison was only three years for science, and the standard deviation was 10 years for age of program. But, when comparing no-participation to the highest in mathematics, a spread of seven years can be seen for math. Also, the mean for non-participation was higher than all other levels and a steady trend was seen. Overall, this was a surprising finding. Younger schools showed a higher level of participation. Older schools showed a decline in participation. This trend was seen in both math and science. Longitudinal studies need to be made to test the trend. It may be that as the school ages, the importance of the performance outcomes begins to outweigh the desire for full participation. When programs are just beginning, for instance, there may be a desire to build numbers of students to maintain class sizes regardless of readiness and, if so, a broader performance might be seen. It would be interesting to look at the pressure on IB teachers to achieve high class scores. Perhaps as the school ages there is a tendency to offer a wider variety of courses that are not IB courses or to allow students to opt out of the testing all together while still participating in the class in order to keep averages as high as possible. This is unclear. A reason for this decrease in participation needs to be investigated further. It would seem that school administrators need to focus the school on a balance of importance between the two objectives, participation and performance.

Host culture and policy implications. Another interesting result was the influence of percent host culture on participation in both math and science. As the percent of host culture student participant increases, participation decreases for mathematics. On the other hand, science participation results show that students at the highest levels come from schools with a high percentage of host culture students. Again, this is has a very small eta-squared. Research into the reasons for monitoring the number of host culture nationals at an international school would be informative. Is it a trend to move from a high percentage of international students to a high percentage of host country nationals as the school ages? How do schools adapt to significant changes in population? School administrators may need to focus on ways to maintain both the level of participation and performance regardless of fluctuations in student clientele.

Math as a Factor in Science Participation

The final research question looked at the relationship between math and science participation. In a comparison of mathematics participation and type of science participation by subject, the results indicate a 'moderately strong' association ($V = .26$).

The association between math participation and chemistry participation was also a 'moderately strong' association (V = .27). The association between math participation and physics was 'strong' (V = .33). In biology there was a 'moderately strong' association (V = .20). Math is a factor that affects participation in IB science subjects, particularly physics. By supporting students in mathematics, educators will also be supporting them in science.

When disaggregating the type of science into subjects of biology, chemistry and physics, a strong gender bias was found in the area of physics and biology. Boys take physics and girls take biology in overwhelmingly higher numbers. The stronger effect size for physics may be related to the gender difference found in math. Prior knowledge in math will affect students in physics. The Cramer's V for physics was .27 in favor of boys, and for biology it was .22 in favor of girls (chemistry was very weak at .04 in favor of boys). If society needs more engineers, then girls must be encouraged to participate more fully in physics. According to the National Science and Math Initiative only ten percent of the American engineers were women in 2008 and Weber, in *Waiting for Superman,* predicts that computer programming and engineering will be two of the positions understaffed by 2020 (NMSI, 2009;Weber, 2010). The comparison between the full world data set and the data set used for this study which excludes the US and Canada was also interesting. Ratios of higher level to standard level indicate that international students are more likely to take chemistry and physics at the higher level than students within the United States. Further research on student participation in North America and the factors that influence this group would be helpful.

Policy Implications and Further Research from the AIS Data

Research findings show that, in general, students at AIS do not push themselves to participate in math or science. Females participate less fully than males in both subjects, even though their overall GPAs are higher. Math results indicate that most students at AIS took mathematics at or below the Math Standard. AIS Math scores are skewed to the right, while the world data set is skewed to the left indicating AIS students are opting for Math Studies more than the world data set. In general, the extent of participation for AIS students in math is 2.8, while the international average is 3.63. The school also had a much wider variance. In science at AIS, students participate slightly below (1.46) the international average of 1.71. This is slightly more than one standard level course. Females participate (1.48) slightly more than males (1.44) in science but markedly lower in math where females average 2.54 and males 3.11 in terms of participation. Even with corrections for non-participation in math (3.16) or science (1.67), both are below international averages.

Each AIS student must take three credits of science to graduate and many students in the sample took no IB science. Students in both math and science took the enough courses to graduate, but may not have chosen IB subjects. Since the IB subjects are AIS's most challenging courses, students are not choosing to take these courses, are not participating fully in science. This may be in part due to the fact that the school has three diploma programs: the American Diploma program, the IB Diploma program and a diploma geared to students entering the local university system. Some students are working toward two or more diplomas. Pressures on the school to meet a variety of student needs should be evaluated in light of the students' ability to participate in math and science course options fully. This has serious implications for both policy and practice. Students in the sample included only those who took IB exams in 2010. Fluctuations in participation in IB math and science subjects from year to year would be seen so a longitudinal view should be taken.

Students may be somewhat unaware of the requirements to enter STEM fields. From the interviews it seems that nearly fifty percent of students wanted to go into these fields but few will be ready to enter university courses, especially if the group averages applied to this small sample. Without some remedial work, most of AIS's students may be disadvantaged when they enter university, if they are considering a STEM path. Part of the trouble may be the nature of the IB program itself. The IBO insists on a well-rounded student with exams in six areas. Perhaps students are taking courses as a way to meet the IB demands rather than contemplating coursework they might need for future objectives. Teachers of students in earlier grades, parents and counselors might help students focus on these future objectives by motivating them appropriately based on apparent skills, PSAT scores and career counseling inventories. By the time the students are in the eleventh grade and have chosen their IB subjects, it may too late to make adjustments. Educational leaders, counselors, teachers and parents need to be aware of society's needs and their role in encouraging students to focus in a given direction. Perhaps enrolling in a full IB program is preventing some students from participating more fully in math and science. For example, one of the top female junior students in the school dropped the full IB in order to take all the sciences at the higher level. Also two high-performing junior US male students (and brothers) chose to not do the full IB diploma because they want to enter STEM fields in the US. All three felt that they needed all the sciences and math available at the higher level (J. Hyde, T. Hyde and W.Y. Suh, personal communication, May 5, 2011). This is not possible to do and complete the full IB Diploma; research into this area might be enlightening. Counselors need to work with students to balance their need for the diploma with their future career needs. This is not an easy task in international schools, where most countries have differing university entry requirements.

Possibly due to the size of the sample, there was no significant relationship with the categorical variables at AIS and participation in either math or science. The numerical variables, on the other hand, were all significant. PSAT-Total, PSAT-Math and GPA were all related to a student's level of participation in both math and science. This indicates that readiness is important for successful participation. The strongest association was seen with PSAT- Math. Student readiness can be seen as a big factor in considering taking Higher Level Mathematics. This finding corroborates previous research findings. Math is a barrier or support for participation in STEM subjects. The PSAT examination is given at the beginning of the 11^{th} grade year and could be used to predict participation. It would be interesting for further study to test if this also predicts high performance in these areas. Unfortunately, however, the test is given too late to inform the student, parent or counselor. The Measures of Academic Progress (MAP) test was just implemented by the school this year and is being given to fourth and eighth graders, perhaps this could serve to predict interest and potential in a more timely fashion to help inform everyone involved. Counselors, teachers and parents could use data from the PSAT-Math, and hopefully the MAP tests, to encourage high achievers to take science and mathematics courses. It seems that despite the relatively high PSAT-Math and PSAT-Total scores earned by students at AIS, the participation was still below the world average. Several students are choosing not to participate at all. Investigation into why this is the case is important.

A descriptive look at the break-down of numbers of students participating in physics, chemistry and biology at AIS shows similar results as the world data-set. Girls, decisively, out-participate boys in biology and boys out-participate girls in physics by an even wider margin. Girls tend to take SL Physics and boys tend to take SL Biology. Boys tend to choose physics at the higher level. Boys tend to take biology (n = 25), chemistry (n = 28) and physics (n = 29) overall at equal rates. Girls however tend to overwhelmingly take biology (n = 61), chemistry (n = 27), physics (n = 11) at very different rates. Five girls took HL Physics in the three year span of the data collected. Overall, more girls took additional courses in science. Girls at AIS are willing to take risks in biology and chemistry but tend not to take them in physics. According to PSAT-Math scores, boys outperform girls, yet girls tend to have a significantly higher GPA. Girls tend to be better students and boys tend to do better on high-stakes testing, like the PSAT. An analysis of the performance at the school would be a worthwhile research investigation. This concurs with findings in the United States and in most other countries. The PSAT can be a measure of ability while GPA is considered a measure of student achievement. AIS personnel need to develop for ways of encouraging all students to take higher level courses, and capable students to take physics. The school needs to promote ways of reducing test anxiety for girls and to encourage girls to take more risks in math and related courses, such as physics. Changes to instructional practice and counseling focus from elementary through high school may encourage more participation.

Interviews. Results from student interviews show that parents and siblings are the most important significant others in terms of choices that students make regarding career and academic goals. Conversations are taking place at home and students are listening to suggestions that parents make. Parents are acting as sounding boards for student concerns. This is important information for the school to understand. Educating parents in career and academic decision-making is very important. Teachers are second in line as a source for student academic and career decision making support. Perhaps teachers should be given more time to engage in these discussions with students. Developing advisory programs that include these types of conversations would allow time for them to occur. Interestingly, counselors were not seen, as a significant-other for academic and career decisions. Perhaps looking at why this is the case might be an important place to start. Counselors may serve a greater need by educating parents and teachers who have more student contact time. The effect peers have in younger grades in making academic decisions might be based on who is in the class, however this was not found by this study.

Limitations of the Study

The study has several delimitations. It focuses on students outside of the United States; on participation, not performance; and on a limited number of IB STEM subjects in science, only biology, chemistry and physics. IB STEM subjects such as Computer Programming, Environmental Systems and Designed Technology were not addressed, due to small sample sizes.

Limitations are also apparent within this study and may also lead to further research. The most evident, is possibly the difficulty in representing the level of participation in science. Developing a measure of the extent of participation, in science in particular, is not straightforward. This may be viewed as a possible limitation because this leads to an ordinal nature of the study, so perhaps lacks some clarity. The differences in the meaning of scales between the mathematics and science participation, for instance, was perhaps not transparent to readers unfamiliar with the IB courses. Further, in order to analyze the relationships properly, the ordinal nature of the participation variables required that they be used as independent variables in the ANOVA test (B. LeBeau, personal communication, June 25, 2011). The choice to study participation rather than performance was made because it is a fundamentally different question and needs to be examined first. If students don't participate, how can they perform? Future studies may delve into at the latter question, a delimiter in this study.

In hindsight it would have been very interesting to look at the effect of the diploma program on participation, by comparing certificate and full-diploma candidates. Universities in different countries may want to question whether they might be eliminating students with the full IB Diploma from courses for which they may otherwise be well-suited, simply because they did not have time in their high school schedule to take program requirements. But, the questions about barriers to full participation may include whether it is possible to participate fully in math and science and still remain a full IB student.

Controlling variables was not part of this study. Modeling, to control variables while analyzing others, would show interactions between math or science participation and the factors more fully.

The data are limited by the demographic data available in the IBO data set. Lack of enough information is one of the limitations of this study. Without ethnicity data with the world data set, the use of UN regional data had to be used. Other program factors, such as the level of technology in the program may impact participation in science and math and might be important to collect from the IB coordinator. This would be particularly pertinent information in light of the standards that the IBO has developed for itself. For instance, Internal Assessments in science have a required technology component (IBO, Physics Guidebook, 2007). How does language ability affect participation and performance in math and science courses? The IB examinations are offered in four languages, but not all first languages of the student's taking the examinations. How does this impact results and course choices? The first language of the student is not given in the data set. How does the existence of the IBO Primary Years Program (PYP) or the IBO Middle Years Program (MYP) affect the level of participation? Research indicates that career decisions may be made earlier in the student's education, which was supported by the interviews. Unfortunately this factor was not investigated and is left for future research.

AIS data presented some limitations as well. The sample size was limited to three years of data and the size of the sample was only 194 students, further, all GPA data were not available. Qualitative interviews were conducted during and after the IB exam period. Time with each student was limited to thirty to forty minutes.

Conclusion

This exploratory study provides some valuable insights into factors that influence participation in mathematics and science courses; this is a pressing global problem. Science and mathematics participation is important in light of the critical need for knowledge workers, with competencies in these areas, to fill necessary positions in the 21st Century workforce. Girls in particular are underrepresented worldwide, though they make up most of the global population (Levine, 2008). Girls also represent most of the students taking IB exams, but are underrepresented in these two key STEM areas. Because of this trend, these areas have received increasing interest by mathematics and science educators as well as policy makers. The choice to study international school students outside of the United States was made because very little research could be found concerning this group. Finding solutions to this issue globally would have the widest benefit to society. Students taking the IB will return to countries around the world and can work to make global changes. Further, globalization and the decrease in the number of people prepared to enter STEM fields, especially within the United States, opens doorways for international students to participate in tertiary academic systems and the global marketplace. Internationals are currently filling the need for students and workers in these areas already. Much of the research to date has been focused on students living in the United States.

The outcomes of this study may provide information to the International Baccalaureate Organization. The IBO mission is to prepare students to enter this 21st Century workforce. While it is not the only organization attempting to do this, exploration of the IBO database does offer an opportunity to investigate factors that may ultimately influence career decision making. Specifically, it offers an opportunity to look at a sample of international students who take courses supported by the same curriculum, monitored by the same internal assessment criteria and resulting in identical external examinations. In essence, several variables are somewhat controlled. This exploratory study may offer a baseline for detailed investigation into factors of interest. It also serves to inform the IBO about whether it is meeting its goals of gender and cultural equity within its program.

The SCCT model has not been tested extensively in international contexts. The data from this study allow a broad look at how nationality and gender might interact with school factors to encourage participation in both math and science IB courses. While this is not an empirical test of the tenets of SCCT, the philosophy of the theory is used and the outcomes may provide empirical evidence for more quantitative tests of the theory in international settings. The hope is that this study will provide inspiration for further research and will help to inform leaders of policy and practice in schools outside of the United States. The IBO may offer a valuable avenue for data collection as well as conversation around these complex but important issues. International school students are an important group of future knowledge workers and deserve the attention of researchers and policy makers because of their potential contribution to the workforce and potential for contributing to the solution of major global issues.

REFERENCES

AAUW. (2005). Public perceptions of the pay gap. Retrieved from http://www.aauw.org/learn/research/upload/perceptionsPayGap.pdf

AAUW. (2008). Where the girls are: Facts about gender equity in education from http://www.aus.org/research/upload/whereGirlsAre.pdf

AAUW. (2010). Why so few? Retrieved from http://www.aauw.org/learn/research/upload/whysofew.pdf

Bandura. (1995). *Self-efficacy in changing societies* (2002 ed.). Melbourne: Cambridge Dedication University Press.

Bandura. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Bandura, A. (1986). *Social foundations of thoughts and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (2002). Preface. In Bandura (Ed.), *Self-efficacy in changing societies* (2002 ed.). Cambridge: Cambridge University Press.

Banks, J. (1988). Ethnicity, class, cognitive and motivational styles: Research and teaching implications. *Journal of Negro Education, 57*(4), 452-466.

BBC. (May 2009). Science gender gap 'widest in UK. Retrieved from http://news.bbc.co.uk/2/hi/uk_news/education/8070745.stm

Beilock, S. (2011). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*.

Betz, N. (2005). Women's career development. In R. L. S. Brown (Ed.), *Career Development and Counseling*. Hoboken, NJ: John Wiley and Sons.

Bhanot, R., & Javanovic, J. (2009). The links between parent behaviors and boys' and girls' science achievement beliefs. *Applied developmental science, 13*(1), 42-59.

Bishop, A., & Forgasz, H. (2007). Issues in access and equity in mathematics education *Second handbook of research on mathematics teaching and learning* (pp. 435-458). Charlotte: Information Age Publishing.

Brown, L., & Gilligan, C. (1992). *Meeting at the crossroads*. Cambridge, MA: Harvard University Press.

Carnevale, A. (2009). Help Wanted: Projections of jobs and education requirements through 2018. Retrieved from http://cew.georgetown.edu/jobs2018/

Chormaic, S., McLoughlin, E., & Gunning, F. (2005). The current situation of women in physics in ireland. Retrieved from http://www.physics.ucc.ie/nicchormaic/Gender_paper.pdf

College Board. (2009). SAT Results. Retrieved from http://www.professionals.collegeboard.com/profdownload/cbs-2009-national-Total-Group.pdf

College Board. (2010). Summary Reports: 2010. Retrieved from http://www.colegeboard.com/student/testing/ap/exgrd_sum/2010.html

Creswell, D. (2008). *Research design: Qualitative, quantitative and mixed methods* (3rd ed.). Thousand Oaks: Sage Publications.

CRC. (2011) Center for Research on Girls at Laurel School, Retrieved from http://www.laurelschool.org/about/CRGatLaurel.cfm

Dee, T. (2007). Teachers and the gender gaps in student achievement. *The Journal of Human Resources, 42*(3).

Department of Labor. (2007). *The Stem workforce challenge*. Employment and Training Administration by Jobs for the Future. Retrieved from http://www.doleta.gov/youth_services/pdf/STEM_Report_4%2007.pdf.

Dweck, C. (2000). *Self theories: Their role in motivation, personality and development*. Hove, East Sussex: Psychology Press, Taylor and Francis Group LLC.

Dweck, C. (2006). Is math a gift? Beliefs that put females at risk. In S.J.Ceci & W.Williams (Eds.), *Why aren't more women in science? Top researchers debate the evidence.* Washington, DC: American Psychological Association.

Eberle, F. (2010). Why STEM is important? Retrieved from http://www.isa.org/InTechTemplate.cfm?template=/ContentManagement/ContentDisplay.cfm&ContentID=83593

Eccles, J. (1986). Gender-roles and women’s achievement. *Educational Researcher*. 15 (6), 15-19

Eccles, J. (2005). Influences of parents' education on their children's educational attainments: The role of parent and child perceptions. *London Review of Education, 3*(3), 191-204.

Elam, J. (2009). *An examination of single-gender and coeducational classes: Their impact on the academic achievement of middle school students enrolled in mathematics and science at selected schools in Georgia.* Ed.D, South Carolina State. Retrieved from http://gradworks.umi.com/34/21/3421367.html

Else-Quest, N. Shibley, J., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. *Psychological Bulletin, 136*(1), 103-127.

Evans, J. (2001). Gender differences in autonomic cardiovascular regulation. *Journal of Applied Physiology, 91*(2611-2618).

Fletcher, J. (2006). Introduction to research methods. Retrieved from http://homes.chass.utoronto.ca/~josephf/pol242/

Friedman, T. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Farrar Straus and Giroux.

Gardner, H. (1989). Multiple intelligences go to school: Educational implications of the theory of multiple intelligences. *Educational Researcher, 18(8)*, 4-9.

Gron, G., & Riepe, M. (2000). Brain activation during human navigation: Gender-different neural networks as substrate of performance. *Nature Neuroscience*(3), 404-408.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*. 18(1),59-82.

Hackett, G. (1985). Role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. *Journal of Counseling Psychology, 32*(1), 47-56.

Halldorsson, A., & Olafsson, R. (2009). The case of island in PISA: girl's educational advantage. *European Educational Research Journal, 8*(1), 34-49.

Harker, R. (2000). Achievement, gender and the single-sex/coed debate. *British Journal of Sociology and Education, 21*(2), 203-218.

Harrison, L. A. (2006). The consequences of stereotype threat on the academic performance of White and non-White lower income college students. *Social Psychology of Education, 9*(3), 341-357.

Hirschi, T., & Selvin, H. C. (1973). *Principles of survey analysis*. New York: Free Press.

Hofstede, G. (1991). *Culture and organizations: Software of the mind*. New York: McGraw Hill.

Howley, C., Strange, M., & Bickel, R. (2000). Research about school size and school performance in impoverished communities. Retrieved from http://www.ericdigests.org/2001-3/size.htm

IBO. (2007). Diploma programme: Physics guide *IBO*. Cardiff: IBO.

IBO (2011). Learner Profile. Retrieved from http://www.ibo.org/programmes/profile/

IBO. (2010). Mission Statement. Retrieved from http://www.ibo.org/mission/index.cfm

IBO. (2010). Statistical Bulletin. Cardiff: IBO.

IBO (2005). Programme standards and practices. Retrieved from http://www.ibo.org/diploma/curriculum/documents/progstandards.pdf

Kuh, C. V. (1998). *Data on women doctoral level scientists and universities.* Paper presented at the National Invitational Conference on Women in Research Universities, Harvard University and Radcliffe College Cambridge Mass.

Lee, V., & Loeb, S. (2000). School size in chicago elementary schools: Effects on teachers' attitudes and students' achievement. *American Educational Research Journal, 37*(1), 3-31.

Lent, R. (2005). A social cognitive view of career development and counseling. In S. B. R. Lent (Ed.), *Career development and counseling: Putting theory and research to work*. Hobeken: Wiley & Sons.

Lent, R., Paixao, M., Silva, J., & Leitao, L. (2009). Predicting occupational interests and choice aspirations in portuguese high school students: a test of social cognitive career theory. *Journal of Vocational Behavior*.

Mertens, D. (1998). *Research methods in education and psychology: Integrating diversity with quantitative and qualitative procedures*. Thousand Oaks: Sage.

Murphy, P., & Whitelegg, E. (2006). A review of the research on participation of girls in physics Retrieved from http://www.iop.org/education/teacher/support/girls_physics/review/file_41599.pdf

Nadel, L., & O'Keefe, J. (1978). *The hippocampus as a cognitive map*. London: Oxford University Press.

Nagy, G., Watt, H., Eccles, J., Trautwein, U., Ludtke, O., & Baumert, J. (2010). The development of students' mathematics self-concept in relation to gender: Different countries, different trajectories? *Journal of Research on Adolescence, 20*(2), 482-506.

NASSPS. (2009). Single sex vs. coed: What's the evidence? Retrieved from http://www.singlesexschools.org/research-singlesexvscoed.htm

National Math and Science Initiative: Competiveness Brochure. (2010) Retrieved from http://www.nationalmathandscience.org/index.php/staying-competitive/competitiveness-brochure.html

NCES. (2009). Executive summary: Highlights from PISA 2009, Retrieved from http://www. nces.ed.gov/pubs2011/2011004.pdf

NCES. (2010). Highlights From Pisa 2009: Performance of US 15-Year-Old Students in Reading Mathematics, and Science Literacy in an International Context. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011004

Nieto, S. (1996). *Affirming Diversity*. White Plains: Longman Publishers.

NMSI. (2008). National Math and Science Initiative: Math and Science are America's Future Retrieved from http://www.nationalmathandscience. org/images/pdf/2008%20annual%20report_low%20res.pdf

Norusis, M. J. (2010). *PASW statistics 18: Guide to data analysis*. Upper Saddle River, NJ: Prentice Hall.

Nosek, B. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. Retrieved from http://www.pnas.org/content/106/26/10593.full.pdf

NSF. (2010). Science and Engineering Indicators: 2010 Retrieved from http://www.nsf.gov/statistics/seind10/pdf/c02.pdf

OECD. (2010). Education at a Glance 2010: OECD Indicators. *Directorate for Education.* Retrieved from http://www.oecd.org/edu/eag2010

OECD. (2011). *Pisa Results 2009.* Retrieved from http://www.oecd.org/dataoecd/54/12/46643496.pdf

Oettingen, G. (1995). Cross-cultural perspectives on self-efficacy. In A. Bandura (Ed.), *Self-efficacy in changing societies*. Cambridge: Cambridge University Press.

PISA. (2010). OECD: Programme for international student assessment, from http://www.pisa.oecd.org/pages/0,3417,en_32252351_32235907_1_1_1_1_1,00.html

Powell, K. (2007). Beyond the glass ceiling. *Nature, 448,* 98-100.

Presmeg, N. (2007). The role of culture in teaching and learning mathematics. In e. Frank Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 435-458). Charlotte: Information Age Publishing.

Ratey, J., & Hagerman, E. (2008). *Spark: The revolutionary new science of exercise and the brain*. New York: Little Brown and Company.

Russell Group. (2009). Briefing: The importance of STEM graduates to the economy. Retrieved from http://www.russellgroup.ac.uk/uploads/STEM-briefing.pdf

Sadker, D., & Sadker, M. (1994). *Failing at fairness*. New York: Touchstone, Simon and Schuster.

Sadker, D., & Zittleman, K. (2009). *Still failing at fairness: How America's schools cheat girl.* New York: Charles Scribners Sons, Macmillan Publishing Co. .

Sapienza, P., Guiso, L., Monte, F., & Zingales, L. (May 2008). Culture, gender and math. *Science*, 1164-1165

Savickas, M. (2005). The theory and practice of career construction. In R. Lent & S. Brown (Eds.), *Career Development and Counseling*. Hoboken: John Wiley and Sons.

Sells, L. (1973). *High school mathematics as a critical filter in the job market.* Paper presented at the Conference on Minority Graduate Education, Berkeley.

Shors, T. (2001). The sex differences and opposite effects on stress and dendritic spine density in male versus female hippocampus. *Journal of Neuroscience, 21*(16), 6292-6297.

Spielhofer, T., O'Donnell, L., Benton, T., Schagen, S., & Schagen, I. (2002). *The impact of school size and single-sex education on performance.* Mere, Upton Park, Slough, Berkshire: National Foundation for Educational Research.

Solberg, V. S., Howard, K. A., Blustein, D., & Close, W. (2002). Career development in schools: Connecting school-to-work-to-life. *The Counseling Psychologist*, *30*(5), 705-725.

Spokane, A., & Cruza-Guet, M. (2005). Holland's Theory of Vocational Personalities in Work Environments. In R. Lent & S. Brown (Eds.), *Career Development and Counseling*. Hoboken: John Wiley and Sons.

Tannen, D. (1996). *Gender and discourse*. New York: Oxford University Press

Terlecki, M., & Newcombe, N. (2005). How important is the digital divide? The relationship of computer videogame usage to gender differences in mental rotation ability. *Sex Roles, 53*(5-6), 433-441.

TAP Coalition. (2008). *Tapping America's potential: The education for innovation initiative*. Retrieved from http://www.tapcoalition.org/news/pdf/tap_progress_press_release.pdf

U.S. Department of Labor, B. L.S. (2003). *Facts on women workers*. Washington D.C. Retrieved from http://www.dol.gov/wb/factsheets/Qf-laborforce-05.htm

Weber, K. (Ed.). (2010). *Waiting for superman: How we can save America's failing public schools*. New York: Public Affairs.

Zimmerman, B. (1995). Self-efficacy and educational development. In A. Bandura (Ed.), *Self-Efficacy in changing societies*. Cambridge: Cambridge University Press.

APPENDICES

Appendix A

IB Learner Profile (IBO, 2005)

IB learners strive to be:

Inquirers They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.

Knowledgeable They explore concepts, ideas and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.

Thinkers They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.

Communicators They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.

Principled They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.

Open-minded They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.

Caring They show empathy, compassion and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.

Risk-takers They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas and strategies. They are brave and articulate in defending their beliefs.

Balanced They understand the importance of intellectual, physical and emotional balance to achieve personal well-being for themselves and others.

Reflective They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development

Appendix B
IBO Standards and Practices

Standard C1
A comprehensive, coherent, written curriculum, based on the requirements of the programme and developed by the school, is available to all sections of the school community.

Practices:

1. A comprehensive, coherent curriculum is available in written form to all sections of the school community (including students, teachers, parents, administrators and members of the governing body).
2. The curriculum is developed with consideration for students' previous learning experiences and future educational needs.
3. The curriculum clearly identifies the skills, concepts, knowledge and attitudes to be taught over time
4. The curriculum places appropriate demands on students according to their age and stage of development, and incorporates issues that are relevant to them.
5. The curriculum encourages students to become aware of individual, local, national and global issues.
6. The curriculum promotes all the attributes of the IB learner profile.
7. The curriculum encourages students to develop strategies for their own learning and assessment, and to assume increasing levels of responsibility in this respect.
8. The curriculum provides ample opportunity for student inquiry and the presentation of ideas.
9. The curriculum provides opportunities for students to work both independently and collaboratively.
10. The curriculum is sensitive to cultural, gender, linguistic, ethnic and religious differences.
11. The curriculum is regularly reviewed in the light of programme developments.
12. The school takes advantage of local community organizations and the expertise of other adults to foster learning within the scope of the curriculum.
13. Where appropriate, the curriculum provides for learning experiences to be made visible to others through displays, posters, public performances etc.
14. The school actively supports the development of the mother-tongue language of all students.

Appendix C

Student Semi-Structured Interviews (30 minutes)

I. Student Interviews Surveys (30 minutes) Apri1 21 – May 30

Framing Interview

1. What do you plan to study at university? (note if different or same from form?)
2. Approximately how old were you when you chose this path?
3. How certain are you about this choice? (1-5)

II. Influences on choice of academic path

The purpose of this interview is to better understand what influence significant others played in your choosing the your current math or science class.

- Put these cards in order of influence concerning your current academic choices.

- Put these cards in order of influence concerning your future academic choices and career goals.

The following will depend on the card sort. Ask about why the top choice in each of the sorts to get further detail. Move down until there seems to be no influence. Repeat with second focus about ongoing academic and career path.

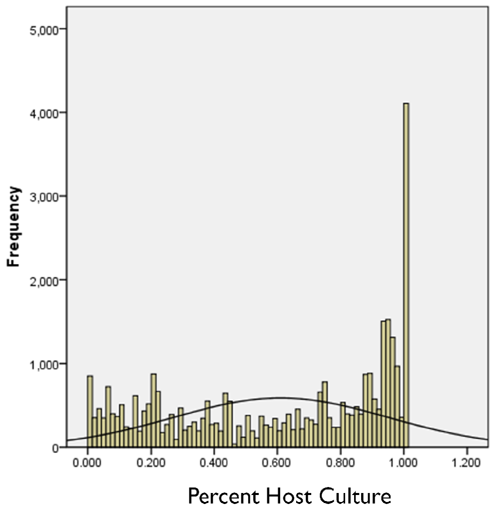
4. Describe the role your parents have played in your extent of participation? (Look for possible themes?? Siblings-order, parents (support, interest), extended family role models?)
5. Describe what role your peers have played in your extent of participation? (Choice of subject due to peers? Enjoy subject because of peers?....college path due to their choice?)
6. Describe what role your teachers played in your extent of participation? (role model, instructional style, subject teacher)
7. Describe what role your counselors have played in your extent of participation?
8. Describe the role others have played in your extent of participation? (Look for possible themes?? Siblings, extended family….)
9. Are there any other influences you care to describe?

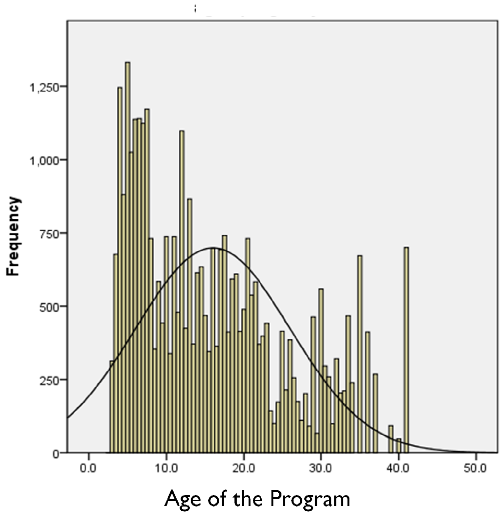
Self - Efficacy

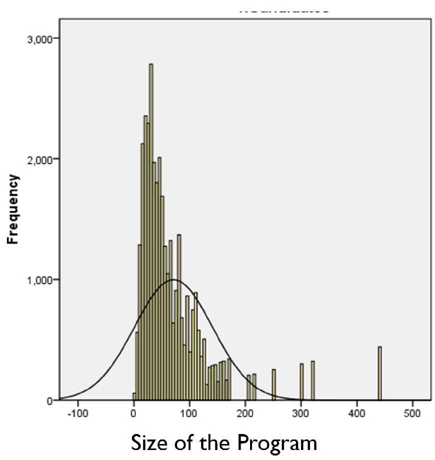
10. How confident are you that you will be successful in this academic/career choice (1-5)?
11. What barriers do you foresee, if any?

Appendix D

Frequency Distributions of Numerical Variables for IB Data







Appendix E

Frequency and Participation by Individual Student Regions

Table 1: Frequency distribution by student region

		Frequency	Percent	Valid Percent	Percent
Valid	Australia/New Zealand	1789	5.1	5.4	5.4
	Central America	455	1.3	1.4	6.7
	Caribbean	26	.1	.1	6.8
	Eastern Africa	679	1.9	2.0	8.8
	Eastern Asia	2940	8.4	8.8	17.6
	Eastern Europe	1389	4.0	4.2	21.8
	Middle Africa	26	.1	.1	21.8
	Northern Africa	231	.7	.7	22.5
	Northern America	2670	7.6	8.0	30.5
	Northern Europe	6435	18.4	19.2	49.8
	South America	4416	12.6	13.2	63.0
	South-central Asia	2257	6.5	6.8	69.7
	South-eastern Asia	2491	7.1	7.5	77.2
	Southern Africa	326	.9	1.0	78.2
	Southern Europe	2598	7.4	7.8	85.9
	Western Africa	246	.7	.7	86.7
	Western Asia	1468	4.2	4.4	91.1
	Western Europe	2992	8.6	8.9	100.0
	Total	33434	95.6	100.0	
Missing	System	1555	4.4		

Table 2: Individual Student Region and Math Participation Cross Tabs

		Math Participation				
		0	2	4	6	Total
Australia/New Zealand	Count	36	587	940	226	1789
	Expected Count	68.8	546.2	796.4	377.6	1789.0
Central America	Count	21	271	138	25	455
	Expected Count	17.5	138.9	202.6	96.0	455.0
Caribbean	Count	1	7	10	8	26
	Expected Count	1.0	7.9	11.6	5.5	26.0
Eastern Africa	Count	9	220	316	134	679
	Expected Count	26.1	207.3	302.3	143.3	679.0
Eastern Asia	Count	200	410	1202	1128	2940
	Expected Count	113.1	897.5	1308.8	620.6	2940.0
Eastern Europe	Count	24	396	604	365	1389
	Expected Count	53.4	424.0	618.3	293.2	1389.0
Middle Africa	Count	1	12	9	4	26
	Expected Count	1.0	7.9	11.6	5.5	26.0

Northern Africa	Count	3	90	88	50	231
	Expected Count	8.9	70.5	102.8	48.8	231.0
Northern America	Count	197	839	1173	461	2670
	Expected Count	102.7	815.1	1188.6	563.6	2670.0
Northern Europe	Count	101	3088	2314	932	6435
	Expected Count	247.5	1964.5	2864.7	1358.3	6435.0
South America	Count	321	1365	2515	215	4416
	Expected Count	169.9	1348.2	1965.9	932.1	4416.0
South-central Asia	Count	57	500	919	781	2257
	Expected Count	86.8	689.0	1004.8	476.4	2257.0
Southeast Asia	Count	71	371	895	1154	2491
	Expected Count	95.8	760.5	1108.9	525.8	2491.0
Southern Africa	Count	4	113	151	58	326
	Expected Count	12.5	99.5	145.1	68.8	326.0
Southern Europe	Count	145	672	1057	724	2598
	Expected Count	99.9	793.1	1156.6	548.4	2598.0
Western Africa	Count	1	66	122	57	246
	Expected Count	9.5	75.1	109.5	51.9	246.0

Western Asia	Count	40	394	753	281	1468
	Expected Count	56.5	448.2	653.5	309.9	1468.0
Western Europe	Count	54	806	1678	454	2992
	Expected Count	115.1	913.4	1332.0	631.5	2992
Total	Count	1286	10207	14884	7057	33434
	Expected Count	1286	10207	14884	7057	33434

Table 3: Individual Student Region and Science Participation

		Science Participation							
		0	1	2	3	4	5	6	Total
Australia/New Zealand	Count	228	585	356	305	305	9	1	1789
	Expected Count	251.2	699.4	377.6	186.5	259.5	11.3	3.6	1789.0
Central America	Count	54	328	63	6	4	0	0	455
	Expected Count	63.9	177.9	96.0	47.4	66.0	2.9	.9	455.0
Caribbean	Count	8	7	2	3	6	0	0	26
	Expected Count	3.7	10.2	5.5	2.7	3.8	.2	.1	26.0
Eastern Africa	Count	113	139	143	86	192	4	2	679
	Expected Count	95.3	265.4	143.3	70.8	98.5	4.3	1.4	679.0
Eastern Asia	Count	550	1040	673	341	329	6	1	2940

	Expected Count	412.8	1149.3	620.5	306.5	426.4	18.6	6.0	2940.0
Eastern Europe	Count	138	760	252	56	157	22	4	1389
	Expected Count	195.0	543.0	293.1	144.8	201.4	8.8	2.8	1389.0
Middle Africa	Count	2	11	6	4	3	0	0	26
	Expected Count	3.7	10.2	5.5	2.7	3.8	.2	.1	26.0
Northern Africa	Count	32	77	54	29	37	2	0	231
	Expected Count	32.4	90.3	48.8	24.1	33.5	1.5	.5	231.0
Northern America	Count	469	902	702	250	334	8	5	2670
	Expected Count	374.9	1043.8	563.5	278.3	387.2	16.9	5.4	2670.0
Northern Europe	Count	866	2461	1381	569	1098	39	21	6435
	Expected Count	903.4	2515.6	1358.1	670.8	933.3	40.8	13.1	6435.0
South America	Count	611	2710	631	379	82	2	1	4416
	Expected Count	620.0	1726.3	932.0	460.3	640.5	28.0	9.0	4416.0
South-central Asia	Count	412	561	478	257	492	36	21	2257
	Expected Count	316.9	882.3	476.3	235.3	327.3	14.3	4.6	2257.0
South-eastern Asia	Count	299	649	418	251	817	57	0	2491
	Expected Count	349.7	973.8	525.7	259.6	361.3	15.8	5.1	2491.0

	Southern Africa	Count	36	75	67	50	98	0	0	326
		Expected Count	45.8	127.4	68.8	34.0	47.3	2.1	.7	326.0
	Southern Europe	Count	367	1082	419	438	291	1	0	2598
		Expected Count	364.7	1015.6	548.3	270.8	376.8	16.5	5.3	2598.0
	Western Africa	Count	9	84	47	21	85	0	0	246
		Expected Count	34.5	96.2	51.9	25.6	35.7	1.6	.5	246.0
	Western Asia	Count	190	525	242	217	285	6	3	1468
		Expected Count	206.1	573.9	309.8	153.0	212.9	9.3	3.0	1468.0
	Western Europe	Count	310	1074	1122	223	234	20	9	2992
		Expected Count	420.1	1169.6	631.4	311.9	433.9	19.0	6.1	2992.0
Total		Count	4694	13070	7056	3485	4849	212	68	33434
		Expected Count	4694.0	13070.0	7056.0	3485.0	4849.0	212.0	68.0	33434.0

Appendix F

Frequencies and Distributions School Region

Table 1: Frequency Distribution by School Region

	Frequency	Percent	Valid Percent	Cumulative Percent
Australia/ New Zealand	1964	5.6	5.6	5.6
Central America	2158	6.2	6.2	11.8
Eastern Africa	803	2.3	2.3	14.1
Eastern Asia	3192	9.1	9.1	23.2
Eastern Europe	1226	3.5	3.5	26.7
Middle Africa	12	.0	.0	26.7
Northern Africa	245	.7	.7	27.4
Northern Europe	6518	18.6	18.6	46.1
South America	4447	12.7	12.7	58.8
South-central Asia	1728	4.9	4.9	63.7
Southeast Asia	3916	11.2	11.2	74.9
Southern Africa	288	.8	.8	75.7
Southern Europe	2694	7.7	7.7	83.4
Western Africa	236	.7	.7	84.1
Western Asia	2137	6.1	6.1	90.2
Western Europe	3425	9.8	9.8	100.0
Total	34989	100.0	100.0	

Table 2: School Region and Math Participation Cross Tabulation

		Math Participation				
		0	2	4	6	Total
Australia/ New Zealand	Count	28	544	1060	332	1964
	Expected Count	82.7	605.4	872.6	403.3	1964.0
Central America	Count	221	886	871	180	2158
	Expected Count	90.9	665.2	958.8	443.1	2158.0
Eastern Africa	Count	14	276	352	161	803
	Expected Count	33.8	247.5	356.8	164.9	803.0
Eastern Asia	Count	193	775	1408	816	3192
	Expected Count	134.5	984.0	1418.1	655.4	3192.0
Eastern Europe	Count	33	349	537	307	1226
	Expected Count	51.6	377.9	544.7	251.7	1226.0
Middle Africa	Count	0	9	0	3	12
	Expected Count	.5	3.7	5.3	2.5	12.0
Northern Africa	Count	17	88	92	48	245
	Expected Count	10.3	75.5	108.8	50.3	245.0

Northern Europe	Count	85	2736	2508	1189	6518
	Expected Count	274.6	2009.3	2895.8	1338.3	6518.0
South America	Count	347	1351	2524	225	4447
	Expected Count	187.3	1370.9	1975.7	913.1	4447.0
South-central Asia	Count	38	421	730	539	1728
	Expected Count	72.8	532.7	767.7	354.8	1728.0
Southeast Asia	Count	208	859	1407	1442	3916
	Expected Count	165.0	1207.2	1739.8	804.0	3916.0
Southern Africa	Count	3	65	168	52	288
	Expected Count	12.1	88.8	128.0	59.1	288.0
Southern Europe	Count	147	726	1074	747	2694
	Expected Count	113.5	830.5	1196.9	553.1	2694.0
Western Africa	Count	1	58	128	49	236
	Expected Count	9.9	72.8	104.9	48.5	236.0
Western Asia	Count	64	571	1066	436	2137
	Expected Count	90.0	658.8	949.4	438.8	2137.0

Western Europe	Count	75	1072	1620	658	3425
	Expected Count	144.3	1055.8	1521.7	703.2	3425.0
Total	Count	1474	10786	15545	7184	34989
	Expected Count	1474	10786	15545	7184	34989

Table 3: School Region and Science Participation Cross-tabulation

		Science Participation							
		0	1	2	3	4	5	6	Total
Australia/ New Zealand	Count	210	628	384	378	350	14	0	1964
	Expected Count	290.7	783.3	403.8	197.2	273.3	11.9	3.8	1964.0
Central America	Count	585	1267	231	42	33	0	0	2158
	Expected Count	319.4	860.7	443.7	216.7	300.2	13.1	4.2	2158.0
Eastern Africa	Count	136	160	213	88	200	3	3	803
	Expected Count	118.8	320.3	165.1	80.6	111.7	4.9	1.6	803.0
Eastern Asia	Count	647	1031	852	298	362	1	1	3192
	Expected Count	472.4	1273.1	656.3	320.6	444.1	19.3	6.2	3192.0
Eastern Europe	Count	89	704	209	64	135	22	3	1226
	Expected Count	181.4	489.0	252.1	123.1	170.6	7.4	2.4	1226.0

Middle Africa	Count	0	6	1	2	3	0	0	12
	Expected Count	1.8	4.8	2.5	1.2	1.7	.1	.0	12.0
Northern Africa	Count	27	75	82	25	36	0	0	245
	Expected Count	36.3	97.7	50.4	24.6	34.1	1.5	.5	245.0
Northern Europe	Count	797	2318	1575	606	1156	41	25	6518
	Expected Count	964.6	2599.6	1340.1	654.6	906.8	39.5	12.7	6518.0
South America	Count	591	2754	632	388	82	0	0	4447
	Expected Count	658.1	1773.6	914.3	446.6	618.7	26.9	8.6	4447.0
South-central Asia	Count	401	467	383	148	302	12	15	1728
	Expected Count	255.7	689.2	355.3	173.5	240.4	10.5	3.4	1728.0
Southeast Asia	Count	596	1154	719	368	1004	70	5	3916
	Expected Count	579.5	1561.9	805.2	393.3	544.8	23.7	7.6	3916.0
Southern Africa	Count	31	64	49	46	98	0	0	288
	Expected Count	42.6	114.9	59.2	28.9	40.1	1.7	.6	288.0
Southern Europe	Count	367	1171	428	445	281	1	1	2694
	Expected Count	398.7	1074.5	553.9	270.6	374.8	16.3	5.2	2694.0
Western Africa	Count	3	86	51	21	75	0	0	236
	Expected Count	34.9	94.1	48.5	23.7	32.8	1.4	.5	236.0

Western Asia	Count	306	670	421	328	396	12	4	2137
	Expected Count	316.3	852.3	439.4	214.6	297.3	12.9	4.2	2137.0
Western Europe	Count	392	1400	964	267	355	36	11	3425
	Expected Count	506.9	1366.0	704.2	344.0	476.5	20.8	6.7	3425.0
Total	Count	5178	13955	7194	3514	4868	212	68	34989
	Expected Count	5178	13955	7194	3514	4868	212	68	34989

Appendix G

Cramer's V Strength of Association (Fletcher, 2006)

LEVEL OF ASSOCIATION	Verbal Description	COMMENTS
0.00	No Relationship	Knowing the independent variable does not reduce the number of errors in predicting the dependent variable at all.
.00 to .10	Not generally useful	Not acceptable
.10 to .20	Weak	Minimally acceptable
.20 to .25	Moderate	Acceptable
.25 to .30	Moderately Strong	
.30 to .35	Strong	
.35 to .40	Very Strong	
.40 to .45	Worrisomely Strong	Either an extremely good relationship or the two variables are measuring the same concept
.45 to .99	Redundant	The two variables are probably measuring the same concept.
1.00	Perfect Relationship.	If we know the independent variable, we can perfectly predict the dependent variable.

Appendix H

Frequency Distributions of AIS Numerical Data