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Experiences That Influence a Student's Choice on Majoring in Physics

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EXPERIENCES THAT INFLUENCE A STUDENT'S CHOICE ON MAJORING IN PHYSICS

by

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Currently the production of college graduates with science and engineering degrees is insufficient to fill the increasing number of jobs requiring these skills. This study focuses on physics majors with an in-depth examination of student transitions from high school to college. Many different areas of influence could affect a student's decision to major in physics. The first phase of this study addresses all of the potential areas of influence identified from the literature. The goal was to identify common influences that might be used to increase students' interest in majoring in physics. Subjects (N=35) from the first phase were recruited from physics majors at diverse Michigan colleges and universities. The second phase of this study explored, in more depth, important areas of influence identified in the first phase of the study. Subjects (N=94) from the second phase were recruited from diverse colleges and universities in Indiana, Illinois, and Ohio. The interviews were also conducted via email.

Approximately half of the students in the study decided to major in physics while still in high school. Their reasons relate to many of the areas of influence. For example, high school physics teachers were cited as a strong influence in many students' decisions to major in physics. Influential physics teachers were described

as being helpful, encouraging and interesting. The teachers also need to be their students' number one cheerleader and not their number one critic.

Some areas of influence were found to be different for males vs. females. A high percentage of all physics majors had influential adults with careers in physical or biological science fields. This percentage was even larger for female physics majors. Female students also showed a greater initial interest in astronomy than the male students. Thus, high school and college physics teachers should seek to expose students to science-related careers and adults with these careers. Astronomy is also an important and often over looked entry into physics.

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Donya Rae Dobbin

TABLE OF CONTENTS

Table of Contents—continued

CHAPTER

Table of Contents—continued

Table of Contents—continued

LIST OF TABLES

LIST OF FIGURES

CHAPTER I: INTRODUCTION

Overview

There is a definite need for more individuals who major in mathematics, science, and engineering. There is also a need to not only look at all students but to take a closer look at the women who could possibly major in these subjects. This study focused on students who are currently majoring in physics. The goal was to identify their reasons for choosing a physics major. Important considerations included an investigation of their transition points from high school to college. The subjects' different areas of influence in their lives were analyzed individually and in combination with each other. Data was collected through email interviews. These interviews were used to find common themes in the subjects' lives that can be used to develop strategies that will help increase other students' interest in majoring in physics. This chapter will provide an overview of rationale for this study and the research goals. Later chapters will provide an in-depth analysis of currently available research, details of the methodology, results, and conclusions from this study.

Need for Skilled Workers

The Committee on Prospering in the Global Economy of the 21st Century stated that "The world economy is growing rapidly in fields that require science, engineering, and technologic skills." (National Academy of Sciences, 2007, p325). This country will need more workers that are skilled in working with the new technology that is being developed. While the number of these careers is increasing, the number of students choosing to study science, mathematics, and engineering continues to decrease (Maple & Stage, 1991 & Seymour & Hewitt, 1997).

After reviewing the 2004 Science and Engineering Indicators the National Science Board stated that "If the trends identified in Indicators 2004 continue undeterred, three things will happen. The number of jobs in the U.S. economy that require science and engineering training will grow; the number of U.S. citizens prepared for those jobs will, at best, be level; and the availability of people from other countries who have science and engineering training will decline" (National Science Board, 2004, p2). This will leave America with a deficit of skilled workers to fulfill these jobs. This can be seen clearly by the numbers of students obtaining a science or engineering degree. From 1966 to 2004, 33% of college bachelor degrees have been in science or engineering (NSF, 2006). The number of jobs for engineers has increased by a growth rate of 1.9% between 1980 and 2000 but the number of bachelor degrees has only increased by 0.1%. The number of jobs for workers with physics degrees has increased by a growth rate of 4.4% between 1980 and 2000 but the number of bachelor degrees awarded has decreased by 1.6%. (Science & Engineering Indicators 2010, Fig. 3-4). While the need has improved and the call for skilled STEM workers increases, the number of students majoring in STEM subjects has not changed. Friedman said it best when he said " We are not producing, in this country, in America, enough young people going into science, technology, and engineering – the field that are going to be essential for entrepreneurship and innovation in the 21st century." (AAPT, 2006).

Need for Women and Minorities

In 1998, only 19% of the bachelor degrees in physics are awarded to women (Hazari, Tai, & Sadler, 2007). This low number of women shows an undeveloped resource for adding to the amount of students who pursue physics and engineering degrees. If women are not pursuing these degrees then the science and engineering communities are losing out on possible talent that could help advance the field (Hazari, Tai, & Sadler, 2007, Turner & Bowen, 1999, & Whitten, Foster, & Duncombe, 2003). These individuals would provide the science and engineering fields with more individuals who might be able to push our country ahead in the race of technology.

Not only is there a major deficit in the number of students going into science and engineering, there is another major deficit in the number of women and minorities pursuing these degrees. This deficit in the number of women and minorities leads to a large discrepancy in the amount of money these groups earn in their careers. "Differences in college major have been found to account for nearly 45% of the difference in earning between men and women" (Solnick, 1995, p505). If the earnings gap is to be minimized more women and minorities need to pursue careers in science and engineering because these are the more profitable careers (Hazari, Tai, & Sadler, 2007, & Maple & Stage, 1991).

Transition from High School to College

Students who are interested in the physical sciences have to make hard decisions in many points of their educational careers. For students who major in physics in college, they frequently need to make decisions to stay invested in their physical science objectives over and over again. There is several key leakage and possible reentry points at which students who have shown interest in the physical sciences stop or return to pursuing education and careers in this area. These key points include: the transition between high school and college, changing majors while in college, and the transition between college and career. A higher percentage of women than men leave the study of the physical sciences at each of these points (Blickenstaff, 2005 & Whitten et al., 2007).

To increase the number of students who obtain a career in the physical sciences, we need to make sure that more students complete a degree in the physical sciences and do not leave the pipeline on their way to this degree. The transition between high school and college is perhaps the most critical leakage point. "It [The scientific/mathematical pool] emerges strongly prior to grade 9 and is essentially complete by grade 12." (Berryman, 1983, p66). This means that a majority of the students who will pursue the physical sciences have this idea before they leave high school. Therefore the greatest loss of students that occurs out of the pipeline towards a completion in a physical science degree is during the transition from high school to college (Maple & Stage, 1991 & Whitten, Foster, & Duncombe, 2003).

According to the Committee on Prospering in the Global Economy of the 21st Century (2007), we need to "enlarge the pipeline of students who are prepared to enter college and graduate with a degree in science, engineering, or mathematics" (National Academy of Sciences, 2007, p129). The Committee suggests that the pursuit of these students start in sixth grade so that the number of students can be greatly increased by the time they reach college. There remains a debate about how to increase the number of these students interested in the pursuit of these fields while they are still in high school.

According to Germeijs & Verschueren (2006) there are six tasks in the process of a student deciding on career and college major. These tasks include orientation to choice, self-exploratory behavior, broad exploratory behavior, in-depth exploratory behavior, decisional status, and commitment. Orientation to choice is the student's awareness that they will need to make a decision about their career choice. The exploratory behaviors are the amount and type of exploration that the student does in determining their career choice. The student's decisional status and commitment is where the student stands in their career decision.

Germeijs & Verschueren (2006) found that these tasks progress in a sequential pattern. Most students make significant progress with their orientation and self-exploratory behavior during their junior year in high school. The frequency of the other exploratory behaviors increases during the student's senior year. The student's decisional status and commitment increase in value during their senior year. Thus, students have made a decision about their career path with a good amount of commitment before they leave high school. According to the study done by Germeijs and Verschueren (2006), students at the end of their twelfth grade year typically ranked 4.49 out of 6 on the commitment to a career scale.

Areas of Influence

The student's world is made up of many different smaller worlds including their families, peers, and school environment. This multiple world model was investigated by Phelan and her colleagues (Phelan, Davidson, & Cao, 1991). They looked into how these different worlds and their interrelationship affected the student's engagement in school. They concluded that "any one [of these worlds] can affect powerfully the direction in which adolescents are pulled " (Phelan, Davidson, & Cao, 1991, p225). These worlds would then have an effect on the student's career decision. We must also keep in mind that the student's world is usually much different than the world of science (Costa, 1995). The interrelationship between the students' multiple worlds and the world of science will play a large role in their physical science career decision.

Focus of the Study

Holes in the Existing Literature

Although much prior research has been conducted to understand how and why students choose to (or not to) major in physics and related subjects, there are several holes in the current body of literature that this study seeks to fill. One way to attract more students to declare physics as a major in college is to pay specific attention to the transition point from high school to college.

Often these studies examine the characteristics of students who choose to major in physics. Two of the studies used the same set of data, High School and Beyond. This data set was collected while the students attended high school up to the time that the students graduated from college. The students involved in this sample graduated from college in the year 1984 and 1986 (Maple & Stage, 1991 & Simpson, 2001). Another study used a data set, College and Beyond, that collected data from three different college freshman classes. The students in these classes were freshman in college in the years 1951, 1976, and 1989 (Turner & Bowen, 1999). The last study that asked students about their high school experience used a sample from 1989 (Eichinger, 1997). One weakness of all of these studies is that they used a sample of students who went to high school and college over twenty years ago.

The few prior studies that have analyzed the students' decision to choose a college major of physics as they are entering college have been quantitative (Eichinger, 1997, Maple & Stage, 1991, Simpson, 2001, & Turner & Bowen, 1999). These studies have used large sets of pre-obtained data. Due to this, the researchers are not able to discover the reasons why students choose a major in physics using the natural language of the students. The researchers are also not able to identify additional hidden reasons that influenced the students' decisions that the researchers may not have thought about a priori. Most of the studies that have been done analyzing the reasons why students choose to leave a major in physics during their college years have been qualitative. The researchers have let the students talk about their reasons in their own language. This has led to different terms and factors being used that the researcher might not have thought about or included in their study. This study will use this approach in the hope to identify a comprehensive set of possible reasons why students choose to major in physics.

Most of these quantitative studies have found connections between the students' backgrounds and the type of major that they choose to study. These background characteristics include gender (Simpson, 2001 & Turner & Bowen, 1999), ethnicity (Maple & Stage, 1991), and number of mathematics courses that the students have taken (Maple & Stage, 1991 & Simpson, 2001). These background characteristics can only be used to predict which students would be more likely to choose a major in physics. The factors that might influence the students' ability, number of mathematics courses, or choice of major are not looked at in depth by these quantitative studies. This study will try to look at the influencing factors in more depth.

Another hole in the prior research is that none of the previous studies have focused on more than a few factors each. There are many different areas that influential factors could arise from. These areas include the students' families, their own personalities, their science teachers, and their exposure to the physics subject itself. Prior studies do not take into account the fact that the students are influenced by each of these areas in their everyday life. Not only will these many areas be taken into account but the interplay between these areas will be considered in this study.

The analogy of the pipeline allows us to consider many different decision points in their educational career when students can leave the study of physical science. One of these times is in the middle of their college years. The many studies that focus on this time period do not take into account what happens in the transition between high school and college (Hazari, Tai & Sadler, 2007, Solnick, 1995, Seymour & Hewitt, 1997, & Whitten, Foster & Duncombe, 2003). Many students enter college with the intention of studying physics and engineering but never complete their degree in either of these subjects. This is an issue for all students but more so for female students. Many studies have focused on these switching students and their perceptions of their college physics classes (Hazari, Tai & Sadler, 2007, Solnick, 1995, Seymour & Hewitt, 1997, & Whitten, Foster & Duncombe, 2003). These studies have found suggestions for the physics teachers and departments at colleges that may lead to more students succeeding in college physics. Would these suggestions also be good for the high school physics teachers and classes? We cannot assume what works for the students their second or third year in college will apply equally to juniors and seniors in high school.

Purpose of Study

According to Germeijs & Verschueren (2006), most students have made a decision about their career path before college. Does this hold true for physics majors or do they make this decision later in their college years? This study will examine when the students first decided to major in physics. It will also look at when the students were exposed to the idea that they could have a career in physics.

There have been many different factors and experiences researched in previous studies of students who major in physics. Many of these studies were done about ten years ago. There is a need to reexamine these factors and experiences to see if they are still present. For example in the past, science teachers' teaching styles did not affect the decision of students to choose between a science or a non-science major. Since then results of educational research has been used to encourage science teachers to teach using a more inquiry and interactive style. If this change has taken place, it could now have an influence on the students' choice of science or non-science majors. This research study will check the previously studied factors and experiences to see if their influence on the students' choice of major has changed.

Most of the studies done on the transition point between high school and college have been quantitative. These studies do not allow the researcher to search for unknown additional factors. This research study is a qualitative study that allows the researcher to let the students drive the search for experiences that have affected their decision between high school and college. This helps expose additional experiences of influence that the researcher may not have thought of before beginning the interviews. This also allows the students instead of the researcher to develop the themes that come out of the area of influences.

Choosing a college major is not a simple decision. There are many different interacting areas that could influence this decision such as family, teachers, and other factors. This research study will not be limited to analyzing only one of these areas of influence. This research study will take into account some of the different areas of influence when looking at the students' choice of college major. The interaction between the areas will be kept in mind while analyzing the information given by the students.

The areas of influence that this study will be focusing on are the following five areas; teachers, subject, parents, self, and peers. The area of influence designated as teachers is about the characteristics and teaching style of the students' high school physics teachers. The subject area is about the overall impression the students have about physics and its career possibilities. The parent area of influence is about the parents overall influence on the students' science related experiences. The area of influence designated as self is about characteristics of the student that may have influenced their choice of college major. The peer area of influence is about the interaction and influence of the students' school community. The students will also be allowed to include any other experiences in different areas of influence that affected their decision.

Many of the previous studies found that students expressed dissatisfaction with the method of teaching that took place in physics classes. This type of teaching did not affect their choice of staying in a science, mathematics, or engineering major (Seymour & Hewitt, 1997 & Whitten, Foster, & Duncombe, 2003) or choosing a science major over a non-science major (Eichinger, 1997). Hazari, Tai, & Sadler (2007) did find that the teaching method affected the students' ability to succeed in a college physics class. They found that the use of history and videos helped the students succeed and the use of computer-based labs and student led projects did not help the students succeed.

This study will examine student perspectives about what types of teaching methods are being used in the high school classroom. It will look to see if the students who choose to major in physics were taught by teaching methods other than didactic. The students will talk about a typical day in their physics classroom so that it can be determined what type of teaching took place a majority of time in the classroom. The students will also be asked about their memorable experiences so that can be determined if any experiences stand out from the normal. If a common set of memorable experiences emerges, then it may be possible to make recommendations about things that should be included in the high school physics curriculum.

Undergraduate students often feel that college physics teachers are unapproachable (Seymour & Hewitt, 1997). Whitten, Foster, & Duncombe (2003) found that the universities and college with more female science majors had teachers who the students felt were more approachable. This study will investigate whether the students who decided to major in physics felt that their physics teachers were approachable.

Maple & Stage (1991) found that parents' expectations had no effect on the students' choice of major. Hazari, Tai, & Sadler (2007) found that fathers had influenced their daughter's ability to succeed in a physics class. They did not investigate whether the father had an influence on their daughter's choice of major. This study will look into what the parents' expectations are for the students who decided to major in physics. It will also look to see if the parents hold higher expectations for females who decided to major in physics.

Maple & Stage (1991) found that the education level of the mother of the student may affect their choice in major. If the mother was a second generation college student then the African-American male students were more likely to major in mathematics and science. This is interesting also because this factor did not seem to affect the females' choice. The proposed study will look into the educational background of the students' parents to see if this could have affected their choice in major. If the parents had gone to college and what the parents might have studied in college could have affected the students' perception of college and science majors.

Both Simpson (2001) and Maple & Stage (1991) found that the more mathematics classes that a student takes in high school, the more likely it is that the student will major in mathematics or science related fields. Simpson (2001) also found that the more science classes that a student takes in high school; the more likely it is that the student will major in a technical field. This does not seem very surprising. The more interesting aspect is not whether a student takes more classes but why do they take more of these classes. This study will look into some of the possible reasons that a student might take more of these types of classes. This choice could be affected by the students' peers, parents, or themselves.

Research Questions

This research study will explore the complex experiences and personal characteristics that influence students' choice of physics as a college major. The major research questions are:

1) When do students first consider choosing a major in physics?
2) What experiences and characteristics influence students' choice of physics as a college major?
    a) What type of teaching methods in high school courses were students who choose physics as a major exposed to?
    b) Do students who choose physics as a major consider their high school physics teachers approachable?
    c) What are the expectations of the parents whose children decide to major

in physics? Is there any gender difference in parent expectations between male and female physics majors?

d) Why do students who choose to major in physics take more math and science classes?

e) Does the parents' education level and focus have an effect on the students decision to major in physics?

Possible Significance of Study

Most of the studies done on the factors that can be used to predict students' college major choice have been quantitative studies. These studies have used predetermined survey instruments that were administered to a large sample. This research study will use a qualitative approach. This allows the researcher to search for influential experiences that might have affected the college major choice that were not anticipated in the design of these quantitative studies. This research study will also allow the students to declare their experiences of influence in their own language. This use of participant language will help to clarify the exact nature of the factors of influence.

There is a crisis occurring in this country. The growth rate for the number of students completing a degree in physics is decreasing. This amount decreased by 1.6% between the years 1980 to 2000 (NSF, 2008). The number of students obtaining a physics degree needs to be increased because the demand for physics degrees is increasing. This amount increased by 4.4% between the years 1980 to 2000 (NSF, 2008). If the growth rate continues at this pace, we will not be able to meet this need.

One way to increase the number of students obtaining a physics degree is to increase the number of entering college students intending to major in physics. This is one of the solutions that Tobias suggests (Tobias, 1990). If more students are entering the major as freshmen in college then more students will graduate from college with a degree in physics, assuming that the rate of switching remains the same. This research study will help identify experiences that influence this choice to major in physics.

By understanding the experiences and characteristics that influence a students' choice to major in physics, we will be able to identify students with these experiences and characteristics. If we can identify students with experiences or interests that are characteristics of physics majors, we will be able to concentrate on these students. A high school physics teacher will be able to encourage and advise these students on the possibilities and rewards of majoring in physics. This added attention may help increase the students' probability of majoring in physics.

Another solution that Tobias suggests is encouraging the students who are capable of pursuing a degree in physics but show little interest in it (Tobias, 1990). By determining which experiences influence students to major in physics, the results of this study may allow high school teacher to predict which students will not choose to major in physics due to a lack of these experiences rather than a lack in ability. There may be ways to substitute other positive experiences for the influential experiences that they are missing. If we are able to make up for these missing experiences, then more of these students may decide to major in physics as well. For example, there may be a need to educate students who do not have a parent in a technical career about the nature of technical careers in a way that is more in-depth than is commonly done. This will allow us to add to the number of students studying physics in college by including the students that Tobias calls the second tier.

CHAPTER II: LITERATURE REVIEW

There have been many previous studies done on the reasons that students major and/or succeed in science and engineering. These studies can be broken into three different types. One type is studies that look at the retention rate in college. These studies attempt to determine the reasons why students stay or leave the science subject during their college years. Four studies of this type are discussed below.

The second type is studies that look at the transition from high school to college. Four studies that are of this type are discussed in this section. These studies used large samples of closed-format surveys to gather their data. The third type is studies that look at students' choices while they are in high school. One study that looked into the reasons why students did not chose to take more physics and chemistry classes in high school is discussed in this section.

During College - Retention

Many of the studies that have been done on increasing the number of students who receive a science or engineering degree have taken place during the subjects' college career (Hazari, Tai, & Sadler, 2007, Seymour & Hewitt, 1997, Solnick, 1995, & Whitten, Foster, & Duncombe, 2003). These studies look into the reasons why students who originally enroll in science or engineering as a major decide to change their majors while they are at college. It is assumed that these findings will also help to determine reasons why students would originally enroll in science or engineering as a major. Many of these studies focus on the female student population, with the aim of increasing the number of female graduates in physics and engineering.

Solnick (1995) studied the difference between the percentages of students switching out of declared majors at public universities versus women's colleges. In the eight women's colleges Solnick used a sample of 1419 students. In the seven coed universities there were 644 men and 698 women. The majors were split into groups of female and male dominated majors. Solnick gathered the percentage of students who declared their major in each group when they entered college and the percentage of students who graduated in each major group.

This data was used to see how many students switched from one major type to the other. Solnick determined that the type of college did not influence the number of women who switched out of male-dominated majors. 78% of the women in the women's college left a male-dominated major while 80% of the women in the coed universities did the same. Male-dominated majors were classified as social sciences, mathematics, computer sciences, engineering, physical sciences, and cultural sciences.

This showed that having female teachers and fellow students was not sufficient to encourage women to stay in male-dominated majors. The gender of students' peers and teachers did not affect the major choice of women. The effects of peers and teachers would be an experience that is placed in the teacher's and peer's area of influence for this study.

Seymour and Hewitt (1997) did a study on the reasons why some students switch out of science, mathematics, and engineering (SME) majors and why other students do not switch. This study was conducted by doing qualitative interviews of students at 7 different universities. Three hundred thirty-five students participated in this study. About half (54.6%) of these students had decided to switch out of a SME major. Seymour and Hewitt found that switchers and non-switchers had the same experiences and largely negative perceptions of their physics courses. It seemed that the main reason why some students switched out of SME majors was due to their inability to cope with some of these experiences.

All of the students reported having similar experiences dealing with teachers in their physics courses at the college level. The method of teaching was one major issue that 83% of the students complained about. The teaching style was didactic and not student centered. The students considered the teachers unapproachable. Sixty-five percent of the students could not find counseling or tutorial help. The grading system that is used in the SME courses were found to be to competitive and therefore detrimental to the students learning. Seymour and Hewitt concluded that these characteristics should be changed in science courses so that students would not have to just try and survive these courses but could instead enjoy learning. These characteristics would be part of the teacher's area of influence.

Whitten, Foster, and Duncombe (2003) did a study on undergraduate women in physics. The purpose of this study was to find out what sets college physics departments apart that have successfully recruited and retained female physics majors. They conducted interviews at nine different universities. Five of these universities had a high female major ratio of about 40% or more. Male students, female students, faculty, and the dean were interview at these universities. Some of the physics classes were observed by the interviewers.

They found that most of the classes taught by these universities were very traditional in their approach (Whitten et al., 2003). The students that were interviewed expressed the desire to have more student-centered teaching styles available. The universities with more female physics students were characterized as having a more approachable atmosphere. Students described this approachability as departments that gave personal attention and had a cooperative spirit. These universities also started recruiting students sooner than the other universities. They had a working relationship with local high schools to make the transition for students easier. These findings are part of the characteristics of the teacher's area of influence in the proposed study. The students' perception of the teachers' approachability and teaching style will be given by the answer to the questions in this area of influence.

Hazari, Tai, and Sadler (2007) studied the reasons why students performed well or not in an introductory level physics course, algebra or calculus based. They surveyed students in 36 different colleges. A total of 1973 surveys were collected. The students were asked about their high school physics experiences and other affective factors that may have influenced their performance. The students' performance was determined by the grades that they received in their physics course.

Several predictors of success in college physics were found. The students' Mathematics SAT score, calculus enrollment, and their high school grades in English, Mathematics, and Science were good predictors of success. Different types of teaching styles were listed as possible predictors of success that may have influenced the students' ability to perform well in their college class. The types of teaching styles that were positive predictors of success were the frequent use of history and videos in teaching physics. One affective factor that was found to influence the female students' ability to perform in their college physics class was their father's encouragement.

A few predictors that have a negative effect on the students' performance in their college physics class were found. Computer-based laboratory activities had a negative influence. More time spent on discussion before and after labs were also a negative influence. If the curriculum was designed around a student-led project, the students did not perform as well in their college physics course.

The students' Mathematics SAT score, calculus enrollment, and high school grades would be classified as characteristics of the students' area of influence in the proposed study. This will not be looked at by determining these measures but by determining the students' perception of their mathematics and science courses. The predictors of success and struggle pertaining to the teachers' teaching style are part of the teacher's area of influence. The father's encouragement of his daughter's pursuit of science was part of the parents' area of influence in the proposed study.

To summarize, these studies focused on the students' performance in their college major and classes. Two of these studies focused particularly on the physics classes themselves (Hazari, Tai, & Sadler, 2007 & Whitten, Foster, Duncombe, 2003). These studies found possible reasons that could help students do well in their major or class using their previous or present teacher's teaching style. There was only one mention of the students' families influence on their ability to stay in their chosen major and do well. From these studies, it is suggested that high school and college teachers should attempt to be more approachable and teach in an innovative way to help students succeed in physics as a college major.

High School to College - Prediction

Some studies have looked into the reasons why students would choose a college major (Eichinger, 1997, Maple & Stage, 1991, Simpson, 2001, & Turner & Bowen, 1999). Some of these studies have looked at large sample sizes of students by using national information databases. The information that is provided in these databases was collected from closed-format surveys using a narrowly defined set of answers. This does not allow the researchers to explore the reasons behind this information. They are not able to ask the students if these are the reasons why they choose their college major.

Turner and Bowen (1999) examined types of college majors. They used the College and Beyond dataset for their information. This dataset included information on students who were freshmen at college in 1951, 1976, and 1989. The information that they used from this dataset included the students Mathematics SAT scores and the major that they choose to study in college. Turner and Bowen found that women with high SAT scores were not more likely to choose a major in mathematics, physics, or engineering. Only about 25% of these high SAT score women choose these majors instead of a major in the life science or humanities. In the comparable group of men 45% choose these majors. The students' Mathematics SAT score would be a prediction factor that may be found in the self's area of influence. In the proposed study, the self area of influence will focus on their attitudes towards mathematics and science and not their actual scores.

The High School and Beyond database was used by two studies (Maple & Stage, 1991 & Simpson, 2001). This database collected data over a twelve year period. The data collection started in the year 1980. The students were in high school at this period of time. Several different variables of information were collected on this dataset. The students were asked questions about their parent's education and influence. They were also asked questions about their own test scores, grades, classes that they had taken, attitudes towards mathematics, and their opinion between the influence of luck or skill on their grades and test scores (Maple & Stage, 1991 & Simpson, 2001).

Simpson's (2001) study focused on the students who had taken the survey as seniors in high school in 1980. The only students that were included in the study were the individuals who had completed a college degree by 1986. Simpson looked at how the variables in the dataset were related to all of the different major choices. She also paid particular attention to the differences between races.

She came to the conclusion that the number of mathematics and science courses that the student took in high school had a positive effect on whether the student would pursue a technical major. If a European American student took calculus in high school, they were 11% more likely to pursue a technical degree. An African American student was 8% more likely to pursue a technical degree. She also noticed that females of any ethnicity were less likely to pursue a technical major than males. There was a 5 to 1 ratio for female students who pursued a health-related degree instead of a technical degree and a 4 to 1 ratio for public service degrees.

Maple and Stage's (1991) study focused on students who had taken the survey as sophomores in high school in 1980. These students included only the individuals who had reported a major field of study by 1984. Maple and Stage look at how the variables in the dataset were related to the students' choices of college major between a mathematics/science major and a non-mathematics/science major. They found that having a mother who was a 2nd generation college attendee had a positive effect on the students' major choice of a science or mathematics related major if the students were African-American males. The parents' expectations seemed to have no effect on the students' major choice. These experiences and characteristics would be the parent's area of influence on the student's choice of major.

The students' positive attitudes towards mathematics made it more likely that they would choose a science or mathematics major if the students were African-American. Taking more mathematics courses in high school had a positive effect on the students' major choice of a science or mathematics related field. This conclusion held true for all ethnicities. The student's attitudes towards their mathematics and science course will be pursued in the proposed study under the self's area of influence. The number and types of science courses that the students took during high school will also be gathered.

Eichinger (1997) did a study also using a survey. This survey was not done at the national level but provided the researcher with similar types of information. Eichinger surveyed 201 students in college about their high school science experiences. He split the sample into 114 science majors and 87 non-science majors. All of these students were classified as academically successful students. The survey in this study asked questions about the teachers' personalities, teaching methods, and the aspect that had the greatest effect on their major decision. Most of the survey was closed-format questions except the last part of the survey. The last part of the survey asked an open-ended question on what factors had the greatest effect on the students' choice of a major.

The results of the closed-format section showed that there was no significant difference in the science teachers' personalities and the teaching methods that were used between the students who majored in science and those who did not major in science. On the open-ended question the students claimed that the biggest effect on their science attitudes was the teachers' style of personal interaction. This would be the way that an individual teacher interacted with the students. This does not seem to be contradictory with the earlier conclusion that there is no difference between the teachers' personality and their major decision. Eichinger does not address this issue.

These studies except Eichinger used national gathered datasets for their samples. This allowed the studies to make conclusions based upon a large sample. These conclusions could also be broken down by college major, gender, and ethnicity. The datasets did not allow the researchers to probe their samples farther to identify the strength of the influence of each of these variables. Most of the variables in the dataset could be used to predict the probability that a student would major in mathematics or science.

During High School - Impressions

Some studies have looked at the students' impression of their high school experience. These results could be used to determine what might increase a students' interest in science. An increased interest in science may result in students taking more science classes while in high school. If there are more students taking more science classes in high school, one might expect to see an increase in the number of students studying science in college.

Terry Lyons (2006) was curious about the falling enrollment of physics and chemistry classes in Australia. He did a study of high school students' impressions of these classes to see why enrollments were steadily decreasing. He surveyed 196 Year 10 students from six different schools. These students were considered as the top 30% of their class. Then 37 of these students were interviewed. Fourteen of these 37 students did not enroll in an additional science course.

The teaching style of the science classes were described as teacher-centered and content-focused. Students in this study were critical of this method. This is what led students to believe science is a subject with only material to be memorized. The students believed that the only way to teach this type of subject, with only material to be memorized and not applied, was teacher-centered and content-focused.

Another negative factor that came out of this study was the fact that the students considered science classes irrelevant and difficult. Students tended not to enroll in additional science courses unless there was a compelling reason to do so. Half of the students did not enroll in higher science classes. Other students made the decision to enroll in higher science classes due to the classes being college prep, encouragement from their parents, or influence by their teachers.

Summary

There were several studies done while the subjects were in college (Hazari, Tai, & Sadler, 2007, Seymour & Hewitt, 1997, Solnick, 1995, & Whitten, Foster, & Duncombe, 2003). These studies followed whether the students switched out of their intended major or not. It was found that female teachers had no effect on the female student population. Most of the students experience was that physics teachers were unapproachable and physics classes had a competitive atmosphere. The students that switched their major had difficulty dealing with this situation. Several other studies looked at national databases for predictors of students who would major in the physical sciences (Maple & Stage, 1991, Turner & Bowen, 1999 & Simpson, 2001). These national databases were written in a closed-format which did not allow the researchers to get more detailed answers. This type of format would allow some possible factors to remain hidden.

Email Interviews

In this study, the methods for obtaining the qualitative interviews were email interviews. The subjects were sent initial questions and followup questions using their school provided email addresses. Meho (2006) examined fourteen studies that used email to conduct in-depth interviews. He compiled a list of advantages and disadvantage of email interviews from the review of these fourteen studies. James (2007) did a study that involved the use of email correspondence to interview the subjects of his study. He created a list of advantages that he found while using email for interviewing his subjects.

Meho and James agree on many of the advantages to email interviewing. They found that it was possible to invite a larger geographically dispersed group of individuals to participate in the study. They also found that the subjects considered their answers to the interview questions in more depth and thought due to the lack of time constraints. James (2007) also found that the subjects produced new ideas due to this lack of time constraint then they may have in face to face interview.

Meho stated some of the disadvantages to using email. This method will limit the subjects to only individuals with internet access. For the individuals that did have internet access some of individuals did not read the recruitment email. While the interviewer was conducting the interview they would not be able to see any non-verbal cues that they subject may be sending.

There are some positive and negatives to email interviews which will be used in this study (Meho, 2006 & James, 2007). Email interviews allow the study to reach a larger geographical area for subjects. The subjects are also provided with more time to think about their answers to the interview questions. The subjects' answers would be missing non-verbal cues that could be found in a face to face interview.

CHAPTER III: METHODOLOGY

This was a qualitative study that attempted to find common experiences and characteristics among physics majors. These experiences and characteristics were broken into five different possible areas of influence. The subjects were asked several questions pertaining to each area of influence so that the interviewer was able to gather as much information as possible about each area of influence.

The population for the first phase of this study was undergraduate physics majors from Michigan universities and colleges. The population for the second phase of this study was undergraduate physics majors from Indiana, Illinois, and Ohio universities and colleges. Limiting the population to these areas was done mainly for convenience since it is not thought that students in the upper-midwest are significantly different from students elsewhere in the United States. However, future, more targeted research could be designed with a national sample. The sample for the first phase was selected from ten universities and colleges that have graduated the most physics majors in Michigan. The sample for the second phase was selected from ten universities and colleges in each state; Indiana, Illinois, and Ohio. It included all different types of institutions from small to large; and private, Christian-based, or public universities and colleges.

The number of subjects from each institution was limited to ten students. This helped to insure that the large university responses did not outweigh the smaller college responses. There were five spots for men and five spots for women from each institution, but sometimes all of these spots were not used. This sampling procedure allowed the researcher to gather a large sample of students for each gender group so that comparisons could be made. Students' names and email addresses were solicited from the department head of each of the target physics departments. Students were recruited to the study via an email invitation. A reminder was sent out five days after the invitation if there was no response. The subjects were chosen randomly from the students who responded to the invitation.

For the first phase, the names and email addresses of undergraduate physics majors from the Michigan universities and colleges were obtained from some of the participating universities and colleges. The invitation email was sent to these students explaining the study that was being conducted. Some of the universities and colleges would not provide the names and email addresses of their undergraduate physics majors. These universities and colleges sent the invitation directly to their students. If a student responded and wanted to participate with the email interview, the researcher sent the consent document to the subject. After they returned their consent document using email, the interview process began. These interviews were broken down into four separate emails containing no more than ten questions each. This broke the interview into a manageable size and allowed the researcher to ask questions about different areas of influence without later questions influencing the subjects' earlier answers. The researcher was also able to ask clarifying questions immediately after the subject had given the responses for that interview section. The sequence of events for phase one is illustrated in figure 1.

Data Collection Activity Timeline for Phase One

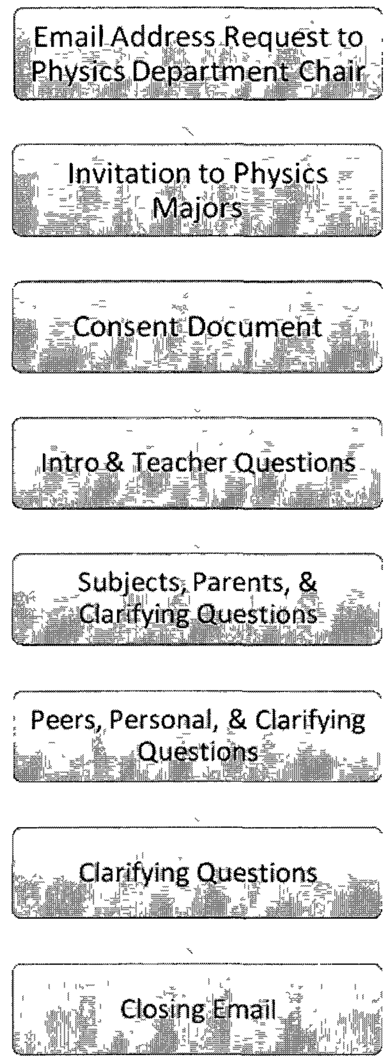

Figure 1: The Sequences of Events to Complete the Interviews in Phase One.

For the second phase, the names and email addresses of undergraduate physics majors from the Indiana, Illinois, and Ohio universities and colleges were obtained from some of the participating universities and colleges. The invitation email was sent to these students explaining the study that was being conducted. Some of the universities and colleges would not provide the names and email addresses of their undergraduate physics majors. These universities and colleges sent the invitation directly to their students. If a student responded and wanted to participate with the email interview, a consent document was sent to the subject.

After they returned their consent document using email, the interview process began. The subjects in the second phase filled out interviews that were sent to them via their school email account. These interviews contain a more targeted set of questions that emerged from the results of the first phase of the study. The researcher also followed up on these interviews with clarifying questions. The sequence of events for phase two is illustrated in figure 2.

Research Design

This study used a qualitative research approach. In this study, the researcher wanted to see the experiences and characteristics that the students had that led to them decide to major in physics. A qualitative research approach allowed for theories and ideas to emerge from the data (Creswell, 2003). This approach could be used to study the reasons behind the decisions made by the student. The focus of this type of study was on the context of the situations that the students were in at the time the decisions were made (Marshall & Rossman, 2006). This study focused on the students' experiences and characteristics that led up to them deciding on a major in physics. Themes for each area of influence were developed from the information that was collected from the participants.

Data Collection Activity Timeline for Phase Two

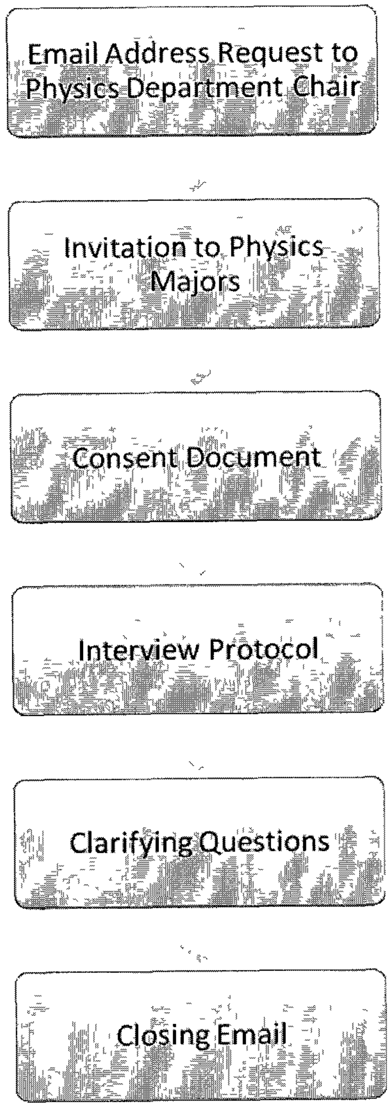

Figure 2: The Sequences of Events to Complete the Interviews in Phase Two.

This study researched the experiences and characteristics individuals have had in their high school years and possibly early college years that may have led them to decide on decide on physics as a major. This type of qualitative study is a phenomenology. Phenomenology is used when the researcher is trying to find a common essence between multiple individuals. This approach can help the researcher explain what the individuals were experiencing when making this decision.

In a phenomenological study the researcher conducted interviews that are in depth. These interviews were analyzed separately. Then the salient points gathered from the analysis were linked together under different themes. These salient points under each theme were then be looked at together to describe the experience of the subjects. It is assumed in a phenomenological study that the individuals have "an essence to an experience that is shared with others" (Marshall & Rossman, 2006, p20).

Data Collection

Phenomenological studies use in depth and multiple interviews to gather information (Creswell, 2007). The interviews were used to gather information about experiences and characteristics that the students had while they were in high school that may have had some effect on their decision to major in physics. Email interviews were used in this study. The use of email interviews has been proposed by some researchers as a good alternative to in-persons or telephone interviews (Hunt & McHale, 2007). In particular email interviews allowed access to subjects who are shy or introverted and who may not want to talk to the researcher on the telephone (Meho, 2006). The researcher believes that most physics students would fall into this category of individual. Further, email interviews gave the subject a stronger sense of anonymity which can increase the honesty of what they tell the interviewer (Hunt & McHale, 2005 & Meho, 2006).

Email interviews also allow the interviewee to complete the interview when and where they wish. In this study, it would have been difficult for the subject and me to coordinate a time and place to meet to conduct the interviews in person or on the phone. Since the interview was done by email the subjects were able to answer the interview questions as their own schedule permitted. They did not have to try to coordinate their own schedule with the researcher's schedule (Meho, 2006). The subjects were able to answer the interview questions wherever they felt the most comfortable doing so (Meho, 2006).

An email interview allowed individuals to take their time answering the interview questions. This allowed the subject to give answers that are more thoughtful and informative (Hunt & McHale, 2005, James, 2007, & Meho, 2006). According to one subject in James' study "writing my story has given me the opportunity to reflect ... in a way that would not happen with the spoken word" (James, 2007, p968). This time for subjects to reflect on their answers before giving them also counteracts another possible issue with email interviews. It may be thought that the subjects did not provide a lengthy response since the researcher was not there to probe the subject's answer. According to another subject in James' study "So my responses were more carefully thought through and probably longer than if I'd tackled the whole thing in a face-to-face interview." (James, 2007, p970). This approach also gave me extra time to create the follow-up questions for the subject.

The length of time and amount of material that the interview needs to deal with is another issue in this study. The email interviews will take longer than an in person interview because the researcher needed to wait for the subject to send their responses before asking clarifying questions or sending the next part of the protocol. Interviews for this study could have lasted as long as a month if the subject took their time responding to the emails. The researcher needed to make sure that she did not take on too many interviews at one time so that the researcher did not get the information confused between individuals. In this study, the number of ongoing interviews was limited to ten.

The participants for the first phase of this study were spread out across the state of Michigan. The participants for the second phase of this study were spread out across the states of Indiana, Illinois, and Ohio. It would have been logistically difficult and much more expensive to conduct these interviews in person (James, 2007). One way that these interviews could have been conducted would have been by phone. A telephone interview would have allowed me to cover this larger geographical region. The other advantages of a telephone interview would have been its ability to work well with shy subjects and allow the subjects to be more spontaneous with their answers (Opdenakker, 2006).

As I have learned, telephone interviews have their own issues. A telephone interview could be interrupted by the subject's ongoing activities. They are also more time consuming due to the fact that the audio must be written (Opdenakker, 2006). Using email interviews allowed me to gather this data in a clear manner from subjects as far away as Michigan Tech (Hunt & McHale, 2005, James, 2007, & Meh, 2006).

Instead of sending an interviewee all of the questions at once, some researchers suggest that it is useful to break a long interview into several smaller pieces, delivered one at a time (Meho, 2006). This is the approach that I chose to adopt. One issue I noticed with using an email system to conduct interviews in the past was the amount of time needed to get a response back from the subjects. Some of the subjects had put off filling out the response items because they felt overwhelmed by the length and had other things that needed to be done. My impression, consistent with Meho (2006) is that the smaller pieces used in this study resulted in a quicker response than I would have if I had sent out the whole interview in one email. This required more emails back and forth to get a full set of responses from each participant. I feel that these additional emails sped up the process, got a better return rate, and also clarified the subject's thoughts better than one long email. This drawn out interview method seemed to help develop a rapport between the subject and me (Hunt & McHale, 2005).

Students from 29 physics departments were involved in the study. In both phases of the study, an invitation was sent to the email addresses of the undergraduate physics majors at a selected university or college. At some of the universities and colleges, the physics department head sent this invitation directly to their students. The email asked students to respond directly to me if they were interested in participating in the study. At other universities and colleges, the physics department head provided me with a list of physics majors. In these cases, I sent invitations directly to randomly chosen students. After a week's time, a reminder was sent to the physics majors who had not responded to the invitation. For the universities and colleges who did not have five students of one gender respond to the invitation more students were chosen and invited to participate. The physics majors from both types of institutions who chose to participate in the study were sent a human subjects consent document. The students were able to return the consent document by email.

After the consent documentation was received from the physics majors, they were sent the first portion of the interview protocol. In this email there were instructions that encourage respondents to provide detailed answers and not worry about correct answers or grammatical errors. The subjects were asked to return their responses within one week. If a subject did not respond in a week, a reminder was sent that included the instructions and protocol. If the subject did not respond to the reminder they were considered to have dropped out of the study.

For the first phase of the study, after the responses to the first portion of the protocol were received the second portion was sent to the subject. This second email included the second portion of the interview protocol plus any clarifying questions about response received from the first portion. This was continued with two additional emails (for a total of four) at which time all of the protocol had been sent to the subject. There was a fifth email sent if necessary with clarifying questions from the last portion of the protocol. For the second phase of the study, after the responses to the first portion of the protocol were received a second email may have been sent which included clarifying question from the first email. After all these questions were answered, the subjects were sent a closing email thanking them for their time and asking for any questions.

When the subjects emailed their responses back, the responses were copied and pasted into a Microsoft Word document. Each subject was assigned a pseudonym that was used throughout the analysis process. For the first phase of the study, there were four separate emails containing five to ten questions that were sent to the subject to cover the entire interview protocol. For the second phase of the study, there was one email containing nine questions that were sent to the subject. The researcher, then, looked at the Microsoft Word document and decided if any additional questions needed to be asked of the subject to help clarify or add to the information. When the subjects responded to these additional emails their responses were copied and pasted back into their Microsoft Word document.

For the first phase of the study, an interview protocol was used to begin the structured interviews. This protocol was divided into the different areas of influence that may have affected the subject's choice of major. The interview questions were based upon different experiences that the subjects may have had in these areas of influence. The areas that may have affected the student's choice of major are family, self, physics teacher(s), physics subject, and peers. This interview protocol is attached to this proposal as part of appendix F.

For the second phase of the study, another interview protocol was used to begin the structured interviews. This protocol contained nine questions. The interview questions for phase two were developed from the interviews in phase one. Additional support and information about the students' influential adults' occupations, high school physics teachers' personality, concerns about careers, and work with real data was necessary to make well founded conclusions and recommendations. This interview protocol is attached to the proposal as part of appendix I.

Sampling

A purposeful sampling method was used in this study. According to Creswell, a purposeful sampling is where the "inquirer selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study" (Creswell, 2007, p125). The subjects for this study were selected based on the fact that they were all attending a Michigan, Indiana, Illinois, or Ohio University or College and have declared physics as their major. These students were able to help inform me about the reasons why they chose physics as a major and what type of experiences they had in junior high and high school that may have affected this choice.

The sites for the first phase of this study included Michigan State University, University of Michigan, Michigan Technology University, Northern Michigan University, Wayne State University, Oakland University, Kalamazoo College, Hope College, Calvin College, and Western Michigan University. The sites for the second phase of this study included ten universities and colleges from each of the following states; Indiana, Illinois, and Ohio. I obtained a list of undergraduate physics majors and their email addresses at some of the universities and colleges. These students were sent an invitation to participate in this study using their email addresses. Some of the universities and colleges sent the invitation to their students directly. Up to five males and five female students at each institution were chosen randomly from the students who responded to the invitation.

Data Analysis

The data analysis that is suggested by Creswell (2007) for a phenomenological study is to highlight the significant statements of the subjects and organize them into themes. This was done in this study by finding the salient points and highlighting them. According to Marshall and Rossman this analytic style is used when the "researcher has assumed an objective stance relative to inquiry and has stipulated categories in advance" (Marshall & Rossman, 2006, p155). The objective for this study was to find common experiences between students who major in physics. The categories that were established in advance were the areas of influence. There were six steps to the data analysis portion of this study. The steps are shown in figure three.

The first step was to collect and organize the subjects' answers to the interview questions. To do this Microsoft Word documents for each individual participant was used. The subject's answers to the interview questions were added to these Microsoft Word documents and organized under the area of influences they pertain to. The areas of influences were embedded in the interview questions so the subjects' Microsoft Word documents were organized into the same order as the interview questions. The next step was to be immersed in the data. The Microsoft Word documents on the participants were read over several times to make sure that the researcher was well informed on the experiences that the subjects had in their high school time period.

In the third step, the individual interviews were read over looking for salient points. The salient points were highlighted in the Word documents. Salient points were created from informative or interesting comments that were made by the subject. The fourth step was to set up Access files for each area of influence. The salient points were copied over to Access files. Identifying factors were listed with the salient points. The identifying factors included gender, student code, school, decision time, age, ethnicity, and parent's education level. Salient points for areas of influence were organized by commonality. These common salient points were given the same theme title.

The fifth step was to create a strength table. In the strength table each individual was listed along one side of the table. On the other side of the table the themes were listed. Xs were placed in the squares for the individuals that had answers that fit with the theme. The sixth step was to write a report that summarized the results of the different sorting relationships. This report stated any similarities that were found between the participants' experiences. The report also stated any difference between groups with different identifying factors.

Data Collection Activity Timeline

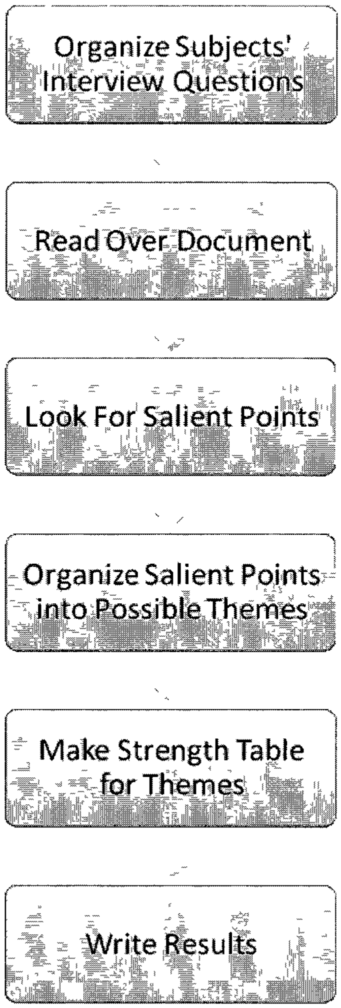

Figure 3: The Sequences of Events to Complete the Data Analysis Process.

Here is an example of this process. A piece of one interview with the salient points underlined is shown below.

"I became seriously interested in physics my senior year in high school, when I took an AP Physics class. I had an excellent teacher, who really helped me learn the material well and also helped me learn to enjoy it. I also realized that I was pretty good at physics.

> Several of my high school teachers encouraged me. My mathematics, physics, and chemistry teachers all encouraged me to do physics. They encourage me mostly on the basis that they could tell that I was gifted in physics and also that I really enjoyed it. "

These salient points were put into a Microsoft Excel spreadsheet and then grouped by themes. The themes from this interview were initial interest teachers, initial interest ability, decision point before high school graduation, encouragement yes, encouragement teacher, and encouragement reinforce.

Limitations

The primary limitation in this study is the use of interviews. The interviews are based upon participants self-reporting their own remembered experiences and reasons for choosing physics as a major. The students may not remember their experiences accurately or the reasons why they choose physics as a major. They may be concerned that the actual reasons for their choice of physics as a major will make them look bad. This self-reporting limitation was mentioned by Marshall and Rossman as a concern to be aware of when using interviews as a data collection model (Marshall & Rossman, 2006).

Another concern to be aware of according to Creswell is the ability of individuals to articulate their decisions (Creswell, 2003). Since email was used as the main form of interview this could be a major concern. The students may not convey the reason for making their decision clearly because the researcher was not there for immediate feedback. They may feel like they have explained it well but the researcher may not get the true picture.

Obtaining and keeping subjects in this study was an issue. The undergraduate physics majors may not have read the invitation letter that was sent to them (Meho, 2006). Sending a reminder invitation should have helped increase the number of individuals who read their invitation letter. Even if a subject decided to participate in the study, they may have dropped out due to their frustration with the progress of the interview (Hunt & McHale, 2005 & Meho, 2006). This frustration could have stemmed from the interview in the first phase being broken into five separate emails. This issue was dealt with as best as possible by increasing the number of subjects accepted into the study. If the subjects did not email back their responses in a week, they were also sent a reminder email with the questions repeated. If the subjects did not respond to this email, they were considered to have dropped out of the study.

The subjects who completed the full set of interview questions will be referred to in the response rate data. The overall response rate for this study was 12.9%. The first phase which contained four to five question emails had a response rate of 19.8%. The second phase which contained one to two question emails had a response rate of 11.4%. The researcher believes that this rate is lower than the phase one rate due to the fact that these students were not from Michigan. The students from Michigan may have been more apt to help another student in Michigan.

The physics department chairs were asked to give me a list of their students and email address so that the researcher would be able to send their students the invitation email. Some physics department chairs decided that they were not comfortable doing this and offered to forward the invitation email to their students for me. The response rate data for the colleges and universities that sent me their students email addresses were 12.5%. The response rate for the colleges and universities that sent the invitation email to their students directly was 13.2%. This response rate was probably more due to the fact that the students were more likely to open the email from their department chair than from an unknown source.

The number of subjects who responded to the invitation email but did not complete all of the question emails were considered to have dropped out of the study. The percentage for the dropout rate was calculated by taking this value out of the number of subjects who responded to the invitation email. The overall dropout rate for this study was 33.8%. The dropout rate for the first phase of the study which had four to five question emails was 25.9%. The dropout rate for the second phase of the study which had one to two question emails was 35.6%. The second phase having a higher dropout rate was a big surprise. Most of these dropouts occurred immediately after the subjects had shown interest in the study but had not completed the consent document. If there were any subjects with a partially completed interview those answers were eliminated from the study.

In email interviews the interviewer is not able to see the body language of the subjects. This may limit the interviewer's ability to interpret the information that the students' report because the researcher may not know how the subject feels about an issue. There are many different symbols that are generally accepted in emails that are used to convey feelings. The subject would have been able to include these symbols in their responses but very few of the subjects did this. The researcher believes that the length of the first phase of this study and the separate emails that the subjects had to answer helped to build a rapport between the interviewer and the subject that also helped to combat this issue. This was evident in the banter that occurred during the interview process with some of the subjects. Many of the subjects also gave long and in depth answers to the interview questions.

Researcher

Part of the procedure suggested by Marshall (2006) for a phenomenological study is to write a statement prior to beginning the study. This statement should include the experience of the researcher in regards to the topic of study. This statement will help the researcher separate their experience from that of the subjects in the study.

The researcher has been a physics and mathematics instructor for ten years. During that time the researcher has taught at the high school, community college, and university levels. The researcher is currently working on my PhD in science education. My major area of research interest is in recruitment and retention of physics students at all levels. The researcher would like to see the number of students who take physics as general education classes grow. The researcher has witnessed students who avoid physics at all costs in high school. In the long run this decision hurts these students in college or their everyday lives.

When I began my college education, I declared my major as mechanical engineering. After a year of college, I changed my major to mathematics and physics secondary education. Even though I did not declare theoretical physics as my major, I was still in a similar major and in the same classes as the physics majors during my early college years. During my later college years instead of the higher level classical mechanics, quantum mechanics, and electrodynamics, secondary education physics majors would take some physics teaching methods courses.

My parent area of influence would be considered typical for a student who pursues a higher education degree in a science field. My parents expected me to do well in school and take classes that were considered more academic. I took four classes in science and six classes in mathematics. I also took these classes because four of each was required for graduation.

My father's job was classified as senior project engineer. He would work on mechanical objects such as the cars or lawn mowers. Sometimes I would help my father work on these objects. I was required to learn how to change the oil in my car before I could get my driver's license. I believe that this helped me pursue my science career because I was not intimidated by the manipulating of tools and mechanical objects. I wonder if this is true for the females that major in physics.

Both of my parents went to college after high school. My mother completed about two years of college before getting married. My father also completed about two years of college and received an associate degree. It was expected that I would attend college to get a four year degree. I did not pursue physics as a degree because it did not seem to be a degree that led directly into a career. Engineering seemed more practical.

If my parents had completed four years of college, I may have known more about the practicality of the bachelor degree.

As for my peer area of influence, I would consider myself typical of an individual who pursues the physical sciences or mathematics field of study. I was not a popular individual with many friends. I did not date while in high school. The friends that I did associate with did not discuss class choices. This would be a description that I would expect from most of the physics majors.

CHAPTER IV: RESULTS

There were two phases to this study. The first phase consisted of four to five e-mail interviews that covered five areas of potential influence on students' selection of physics as a major. The subjects for the first phase of this study were taken from Michigan colleges and universities. There were 35 subjects who participated in the first phase of this study, 22 males and 13 females. The second phase of this study consisted of one to two email interviews. The questions for the second phase of this study were developed utilizing the results of the first phase of the study. The subjects for the second phase of the study were taken from Indiana, Illinois, and Ohio colleges and universities. There were 94 subjects who participated in the second phase of this study, 62 males and 32 females. The total study, both phases one and two, included 129 subjects, 84 males and 45 females. When analyzing the results of this study gender differences were checked for all themes but were only mentioned if they were statistically significant $(\alpha < 0.05)$ or close to being statistically significant. These statistically significant differences will be marked by a * in the tables.

Why Major in Physics

One of the primary research questions of this study was "Why do students choose to major in physics?" This question and students' answers were pursued in both phases of the study; therefore 129 subjects responded to this question. Some subjects gave more than one response to this question. The subjects' responses to this question were themed and these themes were sorted. Table 1 shows the given reasons for choosing to major in physics by theme in both phase one and two of this study. Table 2 shows definitions and examples of each reason.

Table 1
Reasons for Choosing to Major in Physics.

Reason	Percentage of Students (Number of Students)		
	Overall	Male	Female
Found physics classes interesting and challenging.	31.8% (N=41)	28.6% (N=24)	37.8% (N=17)
Enjoyed physics-related books, TV shows, and movies.	20.2% (N=26)	21.4% (N=18)	17.8% (N=8)
Enjoyed application of physics.	17.1% (N=22)	15.5% (N=13)	13.3% (N=6)
Was good at doing physics.	13.2% (N=17)	14.3% (N=12)	11.1% (N=5)
Believed that studying physics had strong career prospects.	11.6% (N=15)	8.3% (N=7)	17.8% (N=8)
Encouraged to study physics by teacher or parent.	11.6% (N=15)	10.7% (N=9)	13.3% (N=6)

In the second phase of this study, students were asked to describe why they were initially interested in physics. This question was asked to see if the reasons would be different from the reasons why the subjects decided to major in physics. It was hoped that some of the topics could be applied to increase the interest of other students. Some of the subjects gave more than one response to this question. Table 3 shows the given reasons that students gave for being initially interested in physics. Table 4 shows definitions and examples of each reason.

Table 2

Examples of the Reasons for Choosing to Major in Physics.

Reason	Definition	Example from Interviews
Found physics classes interesting and challenging.	Enjoyed subject and learning the material more than other subjects.	Physics was too cool and fundamental not to study. Most interesting subject was physics.
Enjoyed physics-related books, TV shows, and movies.	Books, tv shows and movies such as Eureka, Armageddon, An Elegant Universe.	I began to read books about physics and became hooked on the subject.
Enjoyed application of physics.	Like the application and concreteness of the subject.	Worked with particle accelerator. Research as freshman...cement my desire to go into physics
Was good at doing physics.	Better at physics than other students or subjects.	I was one of the top students in the class. It just came naturally.
Believed that studying physics had strong career prospects.	Physics gives an advantage in getting a job or is used as a bonus degree.	97% of physics majors who take MCAT's pass. Greatly increases my chances with getting a job.
Encouraged to study physics by teacher or parent.	Teacher or parent encouraged the student to pursue physics.	High school teacher said go into physics. I got an award for physics 2050.

Decision Point for Major

Another research question posed in this study was, "When do physics majors decide to major in physics?" This question was asked of the 129 students in both phases of the study with 121 students (83 males and 38 females) giving a definitive time period for their decision. Table 5 shows the students point of decision. Many of the answers named their freshman, sophomore, junior, or senior in high school as the time period

Table 3
Reasons for Initial Interest in Physics as a Subject.

Reason	Percentage of Students (Number of Students)		
	Overall	Male	Female
Physics is an interesting and challenging subject.	33.0% (N=31)	24.2% (N=15)	50.0% (N=16)
Teachers helped spur the interest of the students.	20.2% (N=19)	17.7% (N=11)	25.0% (N=8)
Students enjoyed the hands-on activities related to physics.	17.0% (N=16)	17.7% (N=11)	15.6% (N=5)
Students first enjoyed astronomy.*	13.8% (N=13)	8.1% (N=5)	25.0% (N=8)
Students first saw physics concepts in books or tv shows.	12.8% (N=12)	16.1% (N=10)	6.3% (N=2)
Students enjoyed physics due to their ability to do physics.	9.6% (N=9)	12.9% (N=8)	3.1% 9 (N=1)
Parents encouraged the students.	6.4% (N=6)	6.5% (N=4)	6.3% (N=2)
Students enjoyed the structure of the subject.	5.3% (N=5)	4.8% (N=3)	6.3% (N=2)
Students enjoyed the application of the mathematical concepts.	3.2% (N=3)	4.8% (N=3)	0.0% (N=0)

* There is a statistically significant difference between the male and female interest in astronomy at α=0.05. The p-value for this z-statistic is 0.012.

Table 4
Examples of the Reasons for Initial Interest in Physics as a Subject.

Reasons	Definitions	Examples from Interviews
Physics is an interesting and challenging subject.	Students who found physics concepts interesting or challenging.	Interested in how things worked and why
Teachers helped spur the interest of the students.	Students who were inspired by their teachers to pursue physics.	Passion for the physics (teacher) Best teacher…in high school
Students enjoyed the hands-on activities related to physics.	Students who were introduced to physics concepts through toys and activities that they played with.	Childhood interests like legos Rockerty camp
Students first enjoyed astronomy.	Students who enjoyed the concepts of astronomy.	In the country the night sky was amazing. Always held an interest in space and with black holes
Students first saw physics concepts in books or tv shows.	Students who enjoyed physics concepts when presented in books or tv shows.	Bill Nye was a large inspiration Read popular science
Students enjoyed physics due to their ability to do physics.	Students who enjoyed their ability to understand the concepts quicker or better than other students.	Everything "clicked", first time Other students who were copying off of me
Parents encouraged the students.	Students who were encouraged to pursue physics by their parents.	Father kept my interest alive Parents bought me my first telescope for my 13^{th} birthday
Students enjoyed the structure of the subject.	Students who enjoyed the more concrete and less abstract nature of physics.	I loved being able to know why stuff does what it does
Students enjoyed the application of the mathematical concepts.	Students who liked the application of the mathematical concepts.	Great way to link science and mathematical

that they made this decision. These answers were grouped together and labeled as before high school graduation. The others students stated that these decisions occurred while they were in specific classes in college. These answers were grouped together and labeled as during college. Other students stated that these decisions occurred when they were taking time off between high school and college. These answers were grouped together and labeled as after high school graduation. Table 5 shows the given time period that students gave for when they decided to major in physics. Table 6 shows definitions and examples of each time period.

Table 5
Period of Time When Students Made a Decision to Major in Physics.

Period of Time	Percentage of Students (Number of Students)		
	Overall	Male	Female
Before High School Graduation	49.6% (N=60)	48.2% (N=40)	52.6% (N=20)
During College	41.3% (N=50)	42.2% (N=35)	39.5% (N=15)
Time Off	9.1% (N=11)	9.6% (N=8)	7.9% (N=3)

Table 6
Example of Time When Students Made Decision.

Period	Definition	Examples from Interview
Before High School Graduation	Any time before the end of the student's senior year of high school.	Junior in high school Senior in high school Sophomore in high school
During College	Any time after the end of the student's senior of high school whether they were in college, military, or taking time off.	24 years old … time off Second year of college First semester of college
Time Off	Any time after the end of the student's senior year of high school and before going to college for physics.	In military 24 years old Quit my job of 13 years

Subject

One of the potential areas of influence that was investigated in this study was the subject of physics itself. One topic that was derived from this area of influence were the reasons that the students choose to take more science and mathematical classes in high school. This topic was covered in the first phase of the study that was taken by 35 students, 22 male students and 13 female students. Table 7 shows the reasons given for taking more science and mathematical classes by theme. Some subjects gave more than one response to this question. Table 8 shows definitions and examples of each reason.

Table 7
Reasons for Choosing to Take More Science and Mathematics Classes in High School.

Reasons	Percentage of Students (Number of Students)		
	Overall	Male	Female
Students were required to take them and/or encouraged to take them for college prep.	51.4% (N=18)	50.0% (N=11)	53.8% (N=7)
Students were good at them.	40.0% (N =14)	45.5% (N=10)	30.8% (N=4)
Students were required to take them.	37.1% (N=13)	31.8% (N=7)	6.2% (N=6)
Students were encouraged to take them for college prep.	22.9% (N=8)	18.2% (N=4)	30.8% (N=4)
Students enjoyed their concrete concepts.	8.6% (N=3)	9.1% (N=2)	7.7% (N=1)
Students were affected by an outside influence.	5.7% (N=2)	4.5% (N=1)	7.7% (N=1)

Table 8

Examples of Reasons for Choosing to Take More Science and Mathematics Classes.

Reasons	Definition	Examples from Interviews
Students were required and/or encouraged for college prep.	Students were told that they had to take the courses or should to prepare for college.	Only took minimum requirement Basic college prep
Students were good at them.	Students felt comfortable in their ability to perform in these subjects.	Excelled in science courses I've almost always done well
Students were required to take them.	Students were told that they had to take the courses to graduate from high school.	Only took minimum requirement Graduation requirements
Students were encouraged to take them for college prep.	Students were told that they should take the classes to prepare for college.	Basic college prep Preparation for college work
Students enjoyed their concrete concepts.	Students enjoyed the concrete nature of these subjects.	Material more "concrete" Not based on opinion or perspective
Students were affected by an outside influence.	Students took these subjects because they were encouraged to by an outside influence.	Because of Science Olympiad

Another topic that was derived from this potential area of influence was the students' perception of the subject. These topics were also only covered in the first phase of this study. Table 9 shows the given perception that students gave of the subject. Some subjects gave more than one response to this question. Table 10 shows definitions and examples of each perception.

Table 9

Students' Perceptions of Physics as a Subject.

Physics as a subject	Percentage of Students (Number of students)		
	Overall	Male	Female
Challenging	74.3% (N=26)	63.6% (N=14)	92.3% (N=12)
Practical	37.1% (N=13)	40.9% (N=9)	30.8% (N=4)
Interesting	14.3% (N=5)	13.6% (N=3)	15.4% (N=2)
Do Anything	11.4% (N=4)	9.1% (N=2)	15.4% (N=2)
Application of mathematical	11.4% (N=4)	4.5% (N=1)	23.1% (N=3)

Table 10

Examples of Students' Perceptions of Physics as a Subject.

Thoughts	Definition	Examples from Interviews
Challenging	Difficult material	Very difficult field Isn't easy
Practical	Useful to life	Practical Useful to our lives
Interesting	Interesting material	Fascinating Interesting
Do Anything	Good foundation for other subjects or careers	Many possible careers Foundation for the rest of the sciences
Application of mathematics	Mathematics intensive	Science gave mathematics its purpose Heavily math intensive

Teachers

One of the potential areas of influence that was investigated in this study was the students' middle and high school science teachers and the influence they may have had. In the first phase of the study students were asked to describe their high school physics class. Table 11 shows the responses that students gave for a typical day in their high school physics class by theme. A large group of students stated that they took notes or were lectured to during their physics class so these students were grouped into the theme lecture or taking notes. Another group of students stated that they worked on problems during class individually, in groups, or not stated so these students were grouped into the theme of working on problems. Table 12 shows definitions and examples of each reason.

Table 11
Typical Day in a High School Physics Class.

Typical Day	Percentage of Students (Number of Students)		
	Overall	Male	Female
Lecture or Taking Notes	62.9% (N=22)	59.1% (N=13)	69.2% (N=9)
Working on problems individually or in groups.	17.1% (N=6)	18.2% (N=4)	15.4% (N=2)

Table 12
Example of a Typical Day.

Typical Day	Definition	Examples from Interviews
Lecture or Taking Notes	Students remember listening to the teacher lecture and/or taking notes during class.	Lecture Writing notes and examples
Working on problems individually or in groups	Students remember working on physics problems during class.	Work on problems individually Work on assigned homework Working through problems...in groups

Participants were also asked about any unique occurrences that occurred in their high school physics classroom. Some of these responses included discussions on general relativity and trips to an amusement park, Cedar Point. The other students gave responses that did not fit these themes or each other. Table 13 shows the given unique occurrences that students gave that occurred in their high school physics classroom. Table 14 shows definitions and examples of each reason.

Table 13
Unique Occurrences.

Occurrence	Percentage of Students (Number of Students)		
	Overall	Male	Female
Projects	37.1% (N=13)	31.8% (N=7)	46.2% (N=6)
Speakers	5.7% (N=2)	0.0% (N=0)	15.4% (N=2)

Table 14
Examples of the Unique Occurrences.

Occurrence	Definition	Examples from Interviews
Projects	Activities that included using or making hands-on materials.	Homemade rockets Making a cloud chamber
Speakers	Activities that included an influential person speaking to the class.	Speaker from the Chandra X-Ray observatory

The students were asked about their typical day in their high school physics classes. Some of the students provided information about the amount of labs and demonstrations that were done in their classes. Table 15 shows the given frequency that students gave for labs and demonstrations done in their high school physics classroom. Table 16 shows definition and examples for each frequency.

Table 15
The Frequency of Labs and Demonstrations.

Frequency	Percentage of Students (Number of Students)		
	Overall	Male	Female
No Statement about Labs/Demos	42.9% (N=15)	40.9% (N=9)	46.2% (N=6)
Monthly	31.4% (N=11)	27.3% (N=6)	38.5% (N=5)
Daily	17.1% (N=6)	22.7% (N=5)	7.7% (N=1)
Weekly	8.6% (N=3)	9.1% (N=2)	7.7% (N=1)

Another topic that was derived from this area of influence was about the students' physics teacher directly. In both phases of the study, students were asked about the personality and approachability of their high school physics teacher. Table 17

Table 16
Examples of Frequency of Labs and Demonstrations.

Frequency	Definition	Examples from Interviews
No Statement about Labs/Demos	Students did not give an amount in their answers.	Students did not give an amount in their answers.
Monthly	Class contained a few (2-10) labs or demonstrations for the semester.	Two or three a semester Once every three weeks
Daily	Class contained many (30-)labs or demonstrations for the semester.	Lab everyday Labs twice a week
Weekly	Class contained some (10-30) labs or demonstrations for the semester.	Weekly basis Labs once a week

Table 17
Description of the High School Teachers' Personality and Approachability.

Description	Percentage of Students (Number of Students)		
	Overall	Male	Female
Funny/Friendly	33.3% (N=43)	31.0% (N=26)	37.8% (N=17)
Energetic	24.0% (N=31)	20.2% (N=17)	31.1% (N=14)
Individual help	19.4% (N=25)	21.4% (N=18)	15.6% (N=7)
Not approachable	17.8% (N=23)	16.7% (N=14)	20.0% (N=9)
Laid back	2.3% (N=3)	3.6% (N=3)	0.0% (N=0)
Interactive	1.6% (N=5)	6% (N=5)	0.0% (N=0)
Practical	1.6% (N=5)	2.4% (N=2)	6.7% (N=3)

shows the given descriptions that students gave for the personality and approachability of their high school physics teacher. Table 18 shows definitions and examples of each description.

As a follow up to this topic the students in the second phase were asked if their high school physics teachers had a positive effect on their choice in major. Table 19 shows the given effect on their major choice that students gave for their high school

Table 18
Examples of High School Teachers' Personality.

Description	Definition	Examples from Interviews
Funny/Friendly	Teacher jokes around and is a nice person.	Very nice guy. Goofy guy but really nice.
Energetic	Teacher is passionate and enthusiastic about the material.	Was always really excited. Energetic and fun.
Individual help	Teacher is available for help and students feel comfortable asking questions.	At school early. He was available for help.
Not approachable	Teacher is rude or not helpful.	Not very approachable. Loud, harsh, abrasive, and rude.
Laid back	Teacher is relaxed and easy going.	His laid back personality did make physics look as though it wasn't very difficult.
Interactive	Teacher used hands-on and fun experiments.	Very interactive.
Practical	Teacher made the class relate to daily life.	Used his physics to relate to everyday conundrums.

physics teacher. Table 20 shows definitions and examples of each effect. Table 21 shows the given description of their high school physics teacher's personality and effect on their major choice that students gave.

Table 19
High School Teachers' Effect on College Major Choice.

Effect	Percentage of Students (Number of Students)		
	Overall	Male	Female
Positive	50.0% (N=47)	48.4% (N=30)	56.3% (N=17)
No Effect	20.2% (N=19)	21.0% (N=13)	18.8% (N=6)
No Comment	17.0% (N=16)	21.0% (N=13)	9.4% (N=3)
Negative	7.4% (N=7)	6.5% (N=4)	9.4% (N=3)

Table 20

Examples of the Effect on College Major Choice.

Effect	Definition	Examples from Interviews
Positive	Positively affected decision of major or interest in the subject.	Only strengthened my love of science. His personality made me want to go into physics.
No Effect	Teacher did not effect the decision of the student.	I kind of just looked past his personality.
No Comment	Student did not state if the teacher was a positive or negative influence.	
Negative	Teacher deterred the students from physics.	Did give me some doubts about physics.
None	Students did not take physics in high school.	

Table 21

The Relationship Between Teacher Personality and Effect on College Major Choice.

Effect	Personality: Percentage of Students in Column (Number of Students)						
	Funny	Energetic	Ind. Help	Not App.	Laid Back	Interactive	Practical
Positive	89.2% (N=33)	95.5% (N=21)	90.0% (N=9)	0.0% (N=0)	33.3% (N=1)	60.0% (N=3)	80.0% (N=4)
No Effect	6.1% (N=2)	0.0% (N=0)	0.0% (N=0)	50.0% (N=9)	33.3% (N=1)	0.0% (N=0)	0.0% (N=0)
No Comment	6.1% (N=2)	4.5% (N=1)	10.0% (N=1)	11.1% (N=2)	33.3% (N=1)	40.0% (N=2)	20.0% (N=1)
Negative	0.0% (N=0)	0.0% (N=0)	0.0% (N=0)	38.9% (N=7)	0.0% (N=0)	0.0% (N=0)	0.0% (N=0)

Adults

One of the potential areas of influence that was investigated in this study was the students' influential adults. These were the two or three adults that the students felt had the most influence on their lives. In the first phase of the study, the students were asked what level of education their influential adults had reached. One of these male students had four influential adults with a bachelor degree or more from college. Table 22 shows the given amount of influential adults with a bachelor degree or more that students gave. Table 23 shows a definition and examples of a bachelor degree or more.

Table 22
The Level of Education for Their Influential Adults.

Level of College Degree	Percentage of Students (Number of Students)		
	Overall	Male	Female
Bachelors Degree or More			
One Adult	68.6% (N=24)	72.7% (N=16)	61.5% (N=8)
Two Adults	31.4% (N=11)	36.4% (N=8)	23.1% (N=3)

Table 23
Examples of the Level of Education for Their Influential Adults.

Level of College Degree	Definition	Examples from Interviews
Bachelors Degree or More	An adult who earned a Bachelor degree.	Masters Bachelors PhD Bachelors and extra

In the first phase of the study the students were also asked what expectations their influential adults had for their high school education. Table 24 shows the given expectations that the students gave about that their influential adults had for the students' high school education. Some subjects gave more than one response to this question. Table 25 shows definitions and examples of each expectation.

Table 24

The Expectations of the Influential Adults.

Expectations	Percentage of Students (Number of Students)		
	Overall	Male	Female
Good grades	77.1% (N=27)	72.7% (N=16)	84.6% (N=11)
No Control	40.0% (N=14)	40.9% (N=9)	38.5% (N=5)
College	25.7% (N=9)	27.3% (N=6)	23.7% (N=3)

Table 25

Examples of the Expectations of the Influential Adults.

Expectations	Definition	Examples from Interviews
Good grades	Adults expected the student to get good grades in the classes that they were taking.	Expected good grades Perform well in classes To be on the honor roll
No Control	Adults had no expectations of specific classes to be taken by the students.	No expectations about what classes I took Let me take classes as I choose
College	Adults expected the students to prepare to go to college.	Expected to go to college College prep schedule of courses

Students in both studies were asked about their influential adults' careers or type of job. The values given in table 26 show the number of students who stated that they had at least one adult with each type of career. The students named careers for more than one influential adult.

Table 26

Type of Jobs and Careers.

Career of at least one influential adult	Percentage of Students (Number of Students)		
	Overall	Male	Female
Biological or Physical Sciences*	45.7% (N=59)	40.5% (N=34)	55.6% (N=25)
Biological Sciences*	26.4% (N=34)	22.6% (N=19)	33.3% (N=15)
Physical Sciences*	24.0% (N=31)	20.2% (N=17)	31.1% (N=14)
Physical Based	21.7% (N=28)	25.0% (N=21)	15.6% (N=7)
Teacher	15.5% (N=20)	19.0% (N=16)	8.9% (N=4)
Money	10.1% (N=13)	13.1% (N=11)	4.4% (N=2)
Computers	9.3% (N=12)	10.7% (N=9)	6.7% (N=3)
Stay at Home	7.8% (N=10)	8.3% (N=7)	6.7% (N=3)
Sales	7.0% (N=9)	6.0% (N=5)	8.9% (N=4)
Office	6.2% (N=8)	7.1% (N=6)	4.4% (N=2)
Artistic	5.4% (N=7)	6.0% (N=5)	4.4% (N=2)
Police	5.4% (N=7)	3.6% (N=3)	8.9% (N=4)
Owner	3.1% (N=4)	1.2% (N=1)	6.7% (N=3)
Social	3.1% (N=4)	3.6% (N=3)	2.2% (N=1)
Lawyer	3.1% (N=4)	2.4% (N=2)	4.4% (N=2)

* There is a statistically significant difference between the male and female students at $\alpha=0.10$ on three of the types of careers. The p-value for the biological science themes z-statistic is 0.094. The p-value for the physical science themes z-statistic is 0.084. The p-value for the physical or biological jobs z-statistic is 0.051. Although not significant at the $\alpha=0.05$ level, these differences all favor females and suggest that females may benefit more from influential adults in science careers. Additional work is needed to investigate this issue further. Table 27 shows definitions and examples of each career.

Table 27
Example of Jobs and Careers.

Careers	Definitions	Examples from Interviews
Biological or Physical Science	A student that has at least one influential adult with a biological or physical science job.	Doctor, nurse, chemist, engineer
Biological science	A person who works in a field that would use concepts from biology.	Chiropractic, doctor, nurse
Physical science	A person who works in a field that would use concepts from chemistry, physics, or geology.	Chemist, engineer, hydrogeologist, nuclear physicist
Physical based	A person who works in a field that does not require a degree but does require physical skills.	Carpenter, worked on F-15s, electrician, welder
Teacher	A person who teaches any level student or subject.	Physics professor, kindergarten teacher.
Computers	A person who deals with computers hardware or software.	IT manager, software developer
Stay at home	A person who did not have a traditional job.	Stay at home
Office	A person who works primarily in an office setting.	Secretary, human resources
Artistic	A person who works in a creative industry.	Artist, dance, graphic designer
Police	A person who works in law enforcement.	DEA agent, police

Table 27 Continued

Owner	A person who owns any type of business.	Owned a bar, owns business
Social	A person who works in a field that uses concepts from social science fields.	Social worker, psychiatrist
Lawyer	A person who works with the law.	Lawyer

Self

One of the potential areas of influence that was investigated in this study was the physics majors themselves and how their personal choices influence them. One topic that was derived from this area of influence were the type of television shows that the physics majors watched in high school. This topic was covered in the first phase of this study that was taken by 35 students, 22 male and 13 female students. Table 28 shows the given types of television shows that student stated that they watched in high school. Some subjects gave more than one response to this question. Table 29 shows definitions and examples of each type of television show.

Table 28
Type of Television Shows that Physics Majors Watched in High School.

Television Shows	Overall	Male	Female
None	25.7% (N=9)	31.8% (N=7)	15.4% (N=2)
Comedy	25.7% (N=9)	36.4% (N=8)	7.7% (N=1)
Education	17.1% (N=6)	18.2% (N=4)	15.4% (N=2)
Science	17.1% (N=6)	22.7% (N=5)	7.7% (N=1)
Plot	17.1% (N=6)	13.6% (N=3)	23.1% (N=3)
Cartoons	11.4% (N=4)	18.2% (N=4)	0.0% (N=0)

Table 29

Examples of Type of Television Shows that Physics Majors Watched in High School.

Television Shows	Example	
None	Did not watch television	I did not watch much TV
Comedy	Watched comedy sitcoms such as Friends, Seinfeld, Scrubs.	Mix of slapstick and very intelligent humor I watched to laugh
Education	Watched due to the educational value.	PBS shows They made me think History channel
Science	Watched due to the science concepts used in the shows.	It was related to science Crime shows...science and technology presented
Plot	Watched due to the plot lines in the shows.	Like to posit outcomes Liked the struggle they had with solving problems
Cartoons	Watched adult cartoons such as Simpsons and Family Guy.	Simpsons, Family Guy

Another topic that was derived from this area of influence was the type of hobbies that physics majors had in high school. This topic was from the first phase of the study also. Table 30 shows the given types of hobbies that students gave that they participated in during high school. Some subjects gave more than one response to this question. Table 31 shows definitions and examples of each hobby.

Another topic from this area of influence was the students' views on the subjects of mathematics and science. Table 32 shows the themes developed from the students view on the subjects of mathematics and physics. This includes only the first phase of

Table 30
Type of Hobbies that the Physics Majors had in High School.

Hobbies	Percentage of Students (Number of Students)		
	Overall	Male	Female
Sports	37.1% (N=13)	36.4% (N=8)	38.5% (N=5)
Reading	37.1% (N=13)	31.8% (N=7)	46.2% (N=6)
Music	31.4% (N=11)	36.4% (N=8)	23.1% (N=3)
Video games	25.7% (N=9)	36.4% (N=8)	7.7% (N=1)
Internet	8.6% (N=3)	13.6% (N=3)	0.0% (N=0)

Table 31
Examples of Hobbies.

Hobbies	Definition	Examples from Interviews
Sports	Student participated in a sport.	Soccer, skateboarding, sports, athletic
Reading	Student read books.	Historical fiction, reading
Music	Student played on instrument or sang.	Music, playing violin, band
Video games	Student played different types of videogames on gaming systems or computers.	Videogames
Internet	Student used the computer to surf the internet for various reasons.	internet

Table 32
Physics Majors Views on Mathematics and Science.

Views on mathematics and science	Percentage of Students (Number of Students)		
	Overall	Male	Female
Easy	51.4% (N=18)	50.0% (N=11)	53.8% (N=7)
Interesting	20.0% (N=7)	27.3% (N=6)	7.7% (N=1)
Difficult	14.3% (N=5)	13.6% (N=3)	15.4% (N=2)
Boring	14.3% (N=5)	18.2% (N=4)	7.7% (N=1)

the study. Some subjects gave more than one response to this question. Table 33 shows definitions and examples of each views on mathematics and science.

Table 33
Examples of Views on Mathematics and Science.

Views	Definitions	Examples from Interviews
Easy	Students felt that the material was easy.	It came to me pretty naturally Never overly challenged
Interesting	Students felt that the material was interesting.	Never boring On the most part interesting
Difficult	Students felt that the material was difficult.	Extremely frustrating experience The most difficult classes
Boring	Students felt that the material was boring.	Could be boring and annoying

Peers

One of the potential areas of influence investigated in the first phase of this study was the physics majors' peers and their influence on the students' school choices. Table 34 shows the given influence that the students stated that their friends had on the physics majors' high school class choices. Table 35 shows definitions and examples of each influence description.

Table 34
Influence of Friends.

Influence	Percentage of Students (Number of Students)		
	Overall	Male	Female
No Influence	40.0% (N=14)	45.5% (N=10)	30.7% (N=4)
Same classes	31.4% (N=11)	31.8% (N=7)	30.8% (N=4)
Encouraging	20.0% (N=7)	18.2% (N=4)	23.1% (N=3)

Table 35
Example of the Influence of Friends.

Influence	Example	
No Influence	No input into class being taken.	Mostly they didn't have any input.
Same classes	Want their friends to take the same classes.	Wanting all of us to sign up for the same classes.
Encouraging	Encouraged their friends to take science.	Made me feel pretty good about science.

Table 36 shows the given amount that students gave for their dating experiences. Table 37 shows definitions and examples of each dating experience.

Table 36
Physics Majors Dating Experiences.

Dating experiences	Percentage of Students (Number of Students)		
	Overall	Male	Female
Limited	35.0% (N=21)	63.6% (N=14)	53.8% (N=7)
None	20.0% (N=7)	18.2% (N=4)	23.1% (N=3)
Several	17.1% (N=6)	22.7% (N=5)	7.7% (N=1)

Table 37
Example of Physics Majors Dating Experiences.

Dating experiences	Definition	Examples from Interviews
One/two	Student dated one or two individuals in high school.	Had one girlfriend Dated one girl
Limited	Student did not date much during high school or started late.	Began dating as junior Didn't get heavy into dating
None	Student never dated in high school.	Never dated Don't believe in dating
Several	Student dated a lot during high school.	Started dating in 8th Dated alot

Table 38 shows the given cliques that students gave that they participated in during high school. These cliques were determined by the physics majors. The students stated if they felt that they were in variety of cliques, a specific clique, or did not associate with any cliques. When the students stated which cliques they were a part of many of the answers were smart, geeks, or nerds which were combined into one group. Some of the students also stated that they were with the band, choir, or orchestra which was combined into one group. Some subjects gave more than one response to this question. Table 39 shows definitions and examples of each clique.

Table 38
Cliques that Physics Majors were Part of in High School.

Cliques	Percentage of Students (Number of Students)		
	Overall	Male	Female
None	34.3% (N=12)	31.8% (N=7)	38.5% (N=5)
Variety	28.6% (N=10)	31.8% (N=7)	25.0% (N=3)
Smart	22.9% (N=8)	13.6% (N=3)	38.5% (N=5)
Music	17.1% (N=6)	22.7% (N=5)	7.7% (N=1)

Table 39
Example of Cliques.

Cliques	Definition	Examples from Interviews
None	A person who did not associate with any group.	Not in a clique. Kept mostly to myself.
Variety	A person who associate with different groups.	Weren't very well defined cliques. Floater
Smart	A person who associated with other perceived smart students.	Smart kids Nerds
Music	A person who associated with other musically talented students.	Choir geek. Band geek. Orchestra geek.

Follow Up Questions in Phase Two

In the second phase of this study the students were asked what type of encouragement they received to pursue science and physics. This encouragement would have come mainly from the students' influential adults but some of the students' teachers were included in this theme. One of the themes that was pulled from this question was the students who did not receive any encouragement to pursue science and physics.

Table 40 shows the students who stated that they received some or no encouragement to pursue science or physics. Table 41 shows the stated person who gave that encouragement to the physics major to pursue science or physics. Some subjects gave more than one response to this question. Table 42 shows the given type of encouragement that the students stated that they received. Table 43 shows definitions and examples of each type of encouragement.

Table 40
Who Did or Did Not Receive Encouragement to Pursue Science or Physics.

Encouragement	Percentage of Students (Number of Students)		
	Overall	Male	Female
Yes	67.0% (N=63)	62.9% (N=39)	75.0% (N=24)
No	33.0% (N=31)	37.1% (N=23)	25.0% (N=8)

In the second phase of the study the physics majors were asked about their future career plans. Table 44 shows the given job that students gave for their future employment. Table 45 shows definitions and examples of each future job.

Table 41
Who Gave Encouragement.

Person	Percentage of Students (Number of Students)		
	Overall	Male	Female
Parents	47.6% (N=30)	41.0% (N=16)	58.3% (N=14)
High or Middle School Teacher	30.2% (N=19)	25.6% (N=10)	37.5% (N=9)
Physics Professor	17.5% (N=11)	12.8% (N=5)	25.0% (N=6)
Physics Majors	12.7% (N=8)	10.3% (N=4)	16.7% (N=4)
Physics Department	4.8% (N=3)	7.7% (N=3)	0.0% (N=0)

Table 42
Type of Encouragement That the Physics Major Received to Pursue Physics or Science.

Encouragement	Percentage of Students (Number of Students)		
	Overall	Male	Female
Reinforcement	36.5% (N=23)	43.6% (N=17)	25.0% (N=6)
General	30.2% (N=19)	20.5% (N=8)	45.8% (N=11)
Information	30.2% (N=19)	25.6% (N=10)	37.5% (N=9)

Table 43
Examples of Type of Encouragement.

Encouragement	Definition	Examples from Interviews
Reinforcement	Made comments about physics as a possible career or college major.	Suggested...physics would be a good route.
General	Made comments of encouragement about their schooling in general.	General encouragement.
Information	Made comments that provided students with information about physics as a possible career or college major.	Multiple conversation...I found their knowledge fascinating!

Some of the physics majors had participated in research projects during their college careers. The students were asked if these projects affected their choice of physics as a major. Table 46 shows the given effect that students gave that the research project had on their decision to major in physics. Table 47 shows definitions and examples of each effect.

Table 44
Future Job or Field.

Future job	Percentage of Students (Number of Students)		
	Overall	Male	Female
Physics	47.9% (N=45)	50.0% (N=31)	43.8% (N=14)
Other	14.9% (N=14)	16.1% (N=10)	12.5% (N=4)
Engineer	10.6% (N=10)	11.3% (N=7)	9.4% (N=3)
Astronomy	9.6% (N=9)	3.2% (N=2)	21.9% (N=7)
Medical	8.5% (N=8)	8.1% (N=5)	9.4% (N=3)
Don't Know	8.5% (N=8)	11.3% (N=7)	3.1% (N=1)

Table 45
Examples of Future Job.

Future job	Definition	Examples from Interview
Physics	Physics or a branch of physics other than astronomy.	Physics, grad. school
Other	Fields that could not be grouped together.	Pilot, Military, Math, Business
Engineer	Any type of engineer.	Mechanical engineer
Astronomy	Astronomy.	Astrophysics, grad. School
Medical	Medical degree.	Medical school.
Don't Know	Did not know at this time.	Don't know.

Table 46
The Effect of a Research Project on Physics Majors.

Effect	Percentage of Students (Number of Students)		
	Overall	Male	Female
No Research	55.3% (N=52)	51.6% (N=32)	62.5% (N=20)
Postive	16.0% (N=15)	12.9% (N=8)	21.9% (N=7)
No Comment	7.4% (N=7)	9.7% (N=6)	3.1% (N=1)
No Effect	7.4% (N=7)	9.7% (N=6)	3.1% (N=1)
Negative	3.2% (N=3)	4.8% (N=3)	0.0% (N=0)

Table 47

Examples of the Effect of a Research Project.

Effect	Definition	Examples from Interviews
No Research	No research project.	
Positive	Strengthened the student' interest in physics.	Confirm that I wanted to do research.
No Comment	No comment given.	
No Effect	Did not influence the student's decision.	My mind was made up.
Negative	Made student's question their future in physics.	It probably turned me away from research.

Table 48 shows the given major that students gave for the other majors that they considered besides physics when entering college. The theme was reported if more than 3 students gave this response. Some subjects gave more than one response to this question. Table 49 shows definitions and examples of each major.

Table 48

Other Majors Considered.

Other majors	Percentage of Students (Number of Students)		
	Overall	Male	Female
Mathematics	16.0% (N=15)	19.4% (N=12)	9.4% (N=3)
Engineer	14.9% (N=14)	17.7% (N=11)	9.4% (N=3)
Chemistry	12.8% (N=12)	14.5% (N=9)	9.4% (N=3)
Art	9.6% (N=9)	8.1% (N=5)	12.5% (N=4)
Biology	6.4% (N=6)	3.2% (N=2)	12.5% (N=4)
Computer	5.3% (N=5)	8.1% (N=5)	0.0% (N=0)
World Languages	4.3% (N=4)	0.0% (N=0)	12.5% (N=4)
Psychology	4.3% (N=4)	1.6% (N=1)	9.4% (N=3)
None	4.3% (N=4)	6.5% (N=4)	0.0% (N=0)

Table 49
Examples of Other Majors Considered.

Other Majors	Definition	Examples from Interviews
Mathematics	Mathematics	Math
Engineer	Any engineering field.	Engineer, Chemical engineer.
Chemistry	Chemistry	Chemistry
Art	Any creative field.	Theatre, music, film
Biology	Biology	Biology
Computer	Any computer hardware or software field.	Computer programming, Computer science
World Languages	Any foreign language field.	Chinese and Japanese Studies, French major
Psychology	Psychology	Psychology
None	Did not consider other majors.	I didn't really consider any other majors.

CHAPTER V: CONCLUSION

There were two phases to this study. The first phase consisted of four to five email interviews that covered five areas of potential influence on students' selection of physics as a major. The subjects for the first phase of this study were taken from Michigan colleges and universities. There were 35 subjects who participated in the first phase of this study, 22 males and 13 females. The second phase of this study consisted of one to two email interviews. The questions for the second phase of this study were developed utilizing the results of the first phase of the study. The subjects for the second phase of the study were taken from Indiana, Illinois, and Ohio colleges and universities. There were 94 subjects who participated in the second phase of this study, 62 males and 32 females. The total study, both phases one and two, included 129 subjects, 84 males and 45 females. When analyzing results, gender differences were checked for all themes but only mentioned if they were statistically significant at $\alpha = 0.05$ or close to 0.05 (between 0.05 and 0.10).

When Do Students Choose to Major in Physics

One of the research questions for this study was, when do students first consider majoring in physics in college. This question was asked of the students in both phases of the study. About half (49.6%) of the students stated that they decided to major in physics while they were in high school. One student decided to major in physics "after my experiences junior year [in high school physics]". Some of the students went to college with other majors in mind. While they were at college they decided to add or switch their major to physics. These were 41.3% of the students interviewed. One of the students stated that they decided after "starting the astronomy course in my second semester" of college. Another student pointed out that their other courses "weren't as interesting as my physic classes" and this is why they change to a physics major.

Some students did not choose to go to college right after high school or dropped out of college. They decided to attend college later in life. These students choose physics as a major before they decided to go back to school. These students included several different types of situations. Some of these students went to college but decided to leave school in favor of a job. Some of these students got a job right after high school. Some of these students went into the military before going to college. This type of student makes up 9.1% of this studies population. These students were influenced by different life experiences before they went back to school but could have also been influenced by their initial high school experience.

Teaching Methods

The first experience that the study looked into was the type of teaching methods that the students' high school physics teacher used. Previously it was found that the physics teacher's teaching methods did not affect the students' choice of majors (Eichinger, 1997). Since that time, teachers have been encouraged to use more inquiry and interactive teaching styles.

In phase one the students were asked how they would describe their high school class instructor's teaching methods. A majority of the students, 62.9%, described their high school physics class as lecture based or the taking of notes. Some of these students noted that they were allowed to work on problems during class time individually and/or in groups. Eichinger (1997) found 93% of the science majors he interviewed described their science classes as using lecture teaching methods. Still twenty years later this study finds that lecture is a main use of instructional method.

Teacher's Approachability

In a previous study done by Seymour & Hewitt (1997), there were many complaints about the college physics teachers. Seymour & Hewitt looked at students who switched out of SM&E majors and who stayed in the SM&E majors during their college years. One of the traits that these students were asked about was their perception of the ability to get help from their college physics professors. According to the study, 75.4% of the students who switched majors and 52% of the students who did not switch majors stated that it was difficult to get help. This study found that 80% of the students stated that their high school teacher were approachable. This seems to be a significant number of physics teachers who were considered approachable. The approachability may have allowed some students to pursue physics in high school with an open mind that allowed them to continue physics into college.

The students in both phases were asked about the high school physics teacher's approachability. Some students, 13, did not take physics in high school. The other students stated not only if they thought their high school physics teacher was approachable but why they felt their teacher was approachable if he/she was perceived to be so. These results should be used to encourage all physics teachers to keep these positive attributes in mind while they concentrate on teaching the subject. The percentages for the following attributes are based on only the students who had high school physics teachers.

The most common response at 37.1% was that the teachers were funny or friendly. Sometimes high school teachers can get absorbed into the everyday teaching and discipline involved in a high school class and forgets to make it fun. Physics teachers need to remember to show the fun and enjoyable side of physics, not only the challenging side.

Other students stated that their high school physics teacher was approachable due to his or her energy level and enthusiasm. The number of students who mentioned this attribute was 26.7%. One student stated that the teacher's "enthusiasm shown through during his lectures". Another student stated that "his love of the subject was infectious". If we as teachers do not show the excitement of our subject then the students will never be able to see physics as an enjoyable subject to study.

Students also felt that the individual help that the teachers gave was important. The individual help offered by teachers made 21.6% of the students feel that the teachers were approachable. One student stated that "He really cared about how his student did". Another student stated that their high school physics teacher was "quite approachable...he was available for help". From their responses physics teachers can see how offering some help and understanding can have a great effect on the students' impression of them and possibly the subject.

Some students who decided to major in physics stated that their high school physics teacher was unapproachable. This statement was made by 19.8% of the subjects. One student pointed out that "I kind of just looked past [my] high school [teacher's] personality". This shows that there are teachers out there who need to keep their approachability in mind. It is tough enough to get students to major in physics, we don't need them to have to look past the teacher's personality.

Parental Expectations

The parental expectations seemed to have little effect on the students' choice of college major. No theme developed that the parents expected that their students take more science classes or pursue physics specifically. Many of the parents (40.0%) exerted no control on the students' specific class choices in high school. Only 26.0% of the parents expected their students to go to college.

Why More Mathematics and Science Classes

Both Simpson (2001) and Maple & Stage (1991) found that the more mathematics classes that a student takes in high school, the more likely it is that the students will major in mathematics or science related fields. Simpson (2001) also found that the more science classes that a student takes in high school, the more likely it is that the students will major in a technical field. This does not seem very surprising. The more interesting aspect is not if they take more classes but why do they take more of these classes.

In the first phase of this study the students were asked why they took the amount of mathematics and science classes that they did in high school. Two of the top responses were that they were required for graduation or that they were college prep classes. The percentage of students who said they took the classes because they were required was 37.1%. One of the students put it as “only took minimum requirements”. Another student described these classes as “Everyone in my school went through those classes”.

The percentage of students who said they took the classes because they were described as college prep was 22.9% of the students. One student stated these classes were “recommended for college prep”. Since this was a qualitative study students were able to name more than one reason. About half (51.4%) of students stated at least one of these two reasons.

It is important to keep in mind that this study included participants who were only declared physics majors in college. These students would be expected to enjoy and be good at mathematics and science classes. Half of these students only took upper level mathematics and science courses because they felt they had to for requirements or college prep. What does this say about other students who may not be thinking about physics as a possible major and career choice? Education reform initiatives must push to have more mathematics and science courses added onto the high school graduation requirements. If the students do not take these higher level courses in high school they will not have the opportunity to see if they would enjoy physics or other science majors.

Influential Adults

In the first phase of this study the students were asked about the educational background of the influential adults in their lives. The students named two to four adults that they felt influenced them the most. Most commonly, these adults were the students' parents. Some of the other adults named were grandparents, friend's parents, uncles, aunts, and coaches. The adults' educational background seems to have little effect on their college major choice. A majority of students (68.6%) stated that at least one of their influential adults had at least a bachelor degree. Since this is only one adult out of a possible two to four that the students mentioned it does not seem to have a big effect. Only 31.4% of the students stated that they had two influential adults that had at least a bachelor degree.

In both phases of this study the students were asked about the careers of influential adult in their lives. Students could have named more than one career due to having more than one influential adult. Two themes from this topic area were biological and physical science careers. There were 24% of the students who stated that they had at least one influential adult with a physical science career. 26.4% of the same student sample stated that they had at least one influential adult with a biological science career. The percentage of students who had at least one influential adult with a physical or biological science career was 45.7%.

Therefore, almost half of the students who decided to major in physics had a science influence from one of more influential adults in their lives. There is evidence that, in many cases, these students were greatly influenced by the adults. As one stated "I got my curiosity of why things work the way they do by working with him [my father]." Another student showed how having an influential adult with this background was helpful when they stated that they "often asked him questions."

This seems to be a fairly large amount of individuals with these types of jobs for this group. There is no current statistics on the amount of parents of undergraduate students who hold these types of jobs but 3.44% of the adults in the states that were used for this study have a career in science or engineering in 2010 (Science & Engineering Indicators 2010, Table 8-28). Of course we would expect the amount of parents with these types of jobs to be higher for undergraduate students but it would be difficult to believe that it would be as large as 45.7%. There is a very large difference between the careers of the general population and the influential adults of the students in this study.

This implies that these students may have an advantage due to this influence. These students had more exposure to scientific and technological processes through these adults which possibly made them more confident in their ability to pursue a physics degree and obtain a job. Other students without this type of influence may be missing out on an important factor that could push them towards physics. High school teachers need to be aware of this possible missing link in their students' background. The teachers will need to try to help fill in the gaps for these students. Giving these students more attention may be one way to attack this issue of lacking influence and encouragement.

This theme is not only an overall important theme but it is also important for the female students. There is a statistically significant difference at the alpha level of 0.10 between the female and male students in the number of influential adults with these careers. In the biological science careers 22.6% of male students and 33.3% of female students had influential adults with their type of career. This has an alpha value of 0.094. In the physical science careers 20.2% male students and 31.1% female students had influential adults with this type of career. This has an alpha value of 0.084.

Looking at students who had at least one influential adult with a science career is the most significant. There were 40.5% of male students and 55.6% of female students who had one influential adult. This theme for females is almost significant at the 0.050 level. With more research it may be found that this is a significant influential factor in the female students' choice of careers. This study has only begun its look at this issue and was not able to dig deeper as to how this may have influenced the students' choices of careers. It does seem to suggest that female students without influential adults with a science career may need to be given extra information and encouragement so that they may consider physics as a viable major choice for them.

Why Did They Major in Physics

One of the objectives of this study was to determine why students decided to major in physics. It is hoped that educators will be able to use this information to increase the number of students who would consider majoring in physics. Six main reasons were given by participants as to why they chose to major in physics. In order, from the most often given response to least, the reasons are that the subject is interesting, the use of outside materials, the use of hands-on materials, their own ability in the subject, the encouragement from others, and the possibility of future careers. There was no statistically significant difference between the female and male responses.

The number one reason that students chose to major in physics was because the subject matter was interesting. The percentage of students who gave this response was 37.8%. According to one student "It also bored me the least out of anything". Another student stated that they "needed to be challenged". This shows us that as teachers we need to remember that many of the students enjoy the challenging nature of physics. We need to determine which students enjoy the challenge and continuously engage these students in the complexities of the subject.

The next reason that the students choose to major in physics was the influence of outside materials or people. The percentage of students who gave this response was 20.2%. Examples of outside materials are different books, television shows, and movies. One student stated that "Bill Nye was a large inspiration". Another stated "that book … sparked my interest". From these statements we should learn that students are influenced in physics by more than just what is taught in their high school physics classes. Teachers, at the especially elementary levels, should encourage their students to read books and watch shows that may spark their science and physics interest. The teachers could work this information into their lesson plans or mention when certain shows are televised. We also need people to write and create exciting books and shows to spark students' interest when they are young.

The third most often stated reason for majoring in physics was the use of hands-on materials. The percentage of students who gave this response was 17.1%. One student said that the "hands-on stuff made the material more understandable". Another student stated about his/her interest in physics that he/she "really enjoyed (it) because (of) hands-on application". This shows educators that they need to exploit this aspect of the subject to make sure that the students who would be motivated by hands on materials in the study of the subject have the opportunity to engage in it.

Some of the students, 13.2%, stated that they majored in physics because they felt that they were capable of handling the subject. The students were successful in the previous physics courses and enjoyed the feeling of being successful at a "hard" subject. One student even stated "Junior year in high school when for the first time in my education history it was the other students who were copying off of me." This shows that high school teachers need to make sure that students feel successful in this subject area. There needs to be a balance between challenging and rewarding.

Another reason that some of the students stated that they went into physics was because they were encouraged by others. The percentage of students who stated this was 11.6%. One student said that their "high school science teacher said go into physics". This shows what kind of influence some simple encouragement can do for students who are capable in this subject area.

The same amount of students (11.6%) also stated that they majored in physics because of the possible careers. One of the students stated that "Math--based majors are shown to make more money". Another student stated that "physics allows for more fall-back options". This shows that some students look to the future when deciding on their college majors. Educators need to continue to impress upon students what they are able to do with a physics major. They also need to show the students the monetary advantage in their future careers if they have a physic major.

Initial Interest

In the second phase of the study, a question about the students' initial interest in physics was added. The students were asked when and why their initial interest in physics occurred. It was found that more female than male students' initial interest was spurred by astronomy. In the female student sample 25% were initially interested in astronomy while only 8.1% of the male students were initially interested in this topic. This gender difference in the interest of astronomy is shown in the number of astronomy degrees that are given in 2008. The percentage of bachelor degrees given to female in the subject of physics was about 21% and in the subject of astronomy was about 28% (AIP, 2011).

The female students found astronomy topics interesting when they were younger and decided to pursue the study of physics due to this. One female student said she found that "in the country the night sky was amazing". This sparked her interest and she continued to study physics to find more information on this phenomena. Another student stated that she was "interested in astronomy before…physics". This directly shows the connection between physics and astronomy for female students.

This conclusion seems extremely important since it is not only about physics but is specific to the female population. Educators, scientists, and education reform leaders need to work together to emphasize this topic of physics more in the early grades of school. Education reforms need to push for astronomy concepts to be added to content expectations. This will make it a priority to teach these high interest concepts. High school teacher and education reform groups should consider pushing to add astronomy to the state standards in physics. This will allow high school teachers to add an astronomy chapter to their physics classes or an astronomy class in high school.

High School Physics Teacher

The high school physics teacher can have a large impact on their students and their interest in physics. Students were asked what kind of effect their physics teachers had on their college major choice. Half of the students who choose physics as their college major stated that their high school physics teacher had a positive effect on them. When the students were asked what caused their interest in physics, 20% of them said it was due to their high school physics teacher.

The high school physics teacher can have a great influence on their students. One student stated that their high school physics teacher was the "SOLE reason physics is in my life today". Another student stated that their high school physics teacher was "one of the biggest reasons I am majoring in physics". So we can see the huge influence that a high school physics teacher may have.

High school physics teachers need to understand the influence that they have on their students and their interest in physics. They need to keep in mind that they are not only teaching the material but they are also teaching the love of the subject. If the high school physics teacher does not show the interest in the subject needed, then the student will not find the subject interesting.

Summary

There are many interesting findings in this study that ranges across several areas of influence. It was shown that many physics majors took more science and mathematics classes in high school due to the fact that these classes were required or suggested for preparing for college. The majority of these students stated that their high school physics courses were taught in a lecture style. Their high school physics teachers were seen as approachable due to several different behavior traits. The main behaviors that made teachers approachable were reported as their funny or friendly personality, their energy level while teaching the class, and the fact that they gave students individual help. Many of these physics majors stated that their high school physics teacher was a positive influence on their choice of major and helped to stimulate or increase their interest in this major. These physics majors also seemed to have more influential adults with science careers in their lives.

There were two statistically significant separate findings for the female physics majors in this study. Astronomy was an area of physics that initially interested the female physics majors more than the men. This area encouraged the female physics majors to pursue other physics topics. These female physics majors also seemed to be influenced more by their influential adults' careers than the males. There were more influential adults with science careers for the female physics majors than the men.

In this study the physics majors were also asked when they decided to major in physics and why they decided to pursue physics. Half of the students in this study decided to major in physics while they were attending high school. There were many reasons given as to why they decided to pursue physics. Some of the most often cited reasons were that it was interesting, the influence of books and movies, the use of hands-on materials during instruction, their ability in the subject, other people's encouragement, and the possibility of a good career.

Many of these results should be used to positively influence the teaching of physics. Physics teachers should keep in mind that their personality can make a difference in a students' perception of the subject. The physics teachers need to be seen as helpful and encouraging. This will allow students to see physics teachers as approachable, enabling them to feel comfortable asking the physics teacher a questions which will help them pursue their interest in the subject.

Different materials should be considered in the teaching of physics due to these results. The use of hands-on materials should be encouraged in the teaching of physics so that students who find this method intriguing will be interested in the subject. Teachers should bring in or mention different books, magazines, or television shows that discuss physics concepts to their students. Students can then pursue these different materials and may find a new concept or explanation that they find interesting.

Physics teachers need to be their students' number one cheerleader and not their number one critic. Students need to be encouraged by their physics teachers. According to this study physics teachers should praise students for their ability to understand physics. This has been shown to influence many students to choose to study physics. Physics teachers should also point out all of the possibilities for careers with the knowledge found in the study of physics. It would also be encouraging for all students, but especially female students, to connect them with adult mentors. Adult mentors should be adults who have careers that use physics concepts so the students can see the connection between the subject and a real-life career.

Physics educators at all levels need to monitor and push for more high school requirements. More mathematics classes need to be required to graduate from high school to help prepare students to pursue all science programs in college. Encouraging more schools to have an astronomy class as an elective in high school could help open up more female students to the possibility of pursuing the study of physics. Physics needs to be required to graduate from high school to help make sure all students are exposed to physics concepts.

Future Research

There are two important themes from this study that should be pursued further in research. These themes are the physics teacher's approachability and the role of science careers of the influential adults and their effect on students. One possible future study would focus on the high school physics teachers personality and approachability and its effect on the students choice of major. In pursuing this study, I would take several current high school physics classes and interview as many of the students as possible. I would ask the students to describe their high school physics teacher's personality and approachability and its effect on them as students. I would interview these students again when they are in college and record their initial college major choice. This study could be used to see if there is a statistically significant relationship between approachability and college major choices. It could also be used to see if the high school physics teacher's personality greatly influences the students' perception of physics.

College physical science students could be interviewed about their influential adult's careers in more depth. The type of career, the student's exposure to the career, and perceived effect should be addressed. This would look at specific reasons why the students' influential adult's careers have a large influence on their college major choice. This would allow us to duplicate this experience for students who do not have these types of influential adults.

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Appendix A

HSIRB Approval Letter for Phase One

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: October 21, 2008

To: Charles Henderson, Principal Investigator
Donya Dobbin, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number: 08-09-18

This letter will serve as confirmation that your research project entitled "Experiences that Influence a Student's Choice on Majoring in Physics" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 21, 2009

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix B

HSIRB Approval Letter for Phase Two

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: November 2, 2009

To: Charles Henderson, Principal Investigator
Donya Dobbin, Student Investigator

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number: 09-10-20

This letter will serve as confirmation that your research project titled "Experiences that Influence a Student's Choice on Majoring in Physics – Phase 2" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: November 2, 2010

Walwood Hall, Kalamazoo, MI 49008-5456
PHONE: (269) 387-8293 FAX: (269) 387-8276

Appendix C

Email to Physics Department Chair for Phase One

Subject Line: Research study that needs your help.

Dear Department Chair

I am a PhD student in physics education from Western Michigan University and a high school physics teacher. While working on my dissertation project, I hope to interview physics major students. These interviews will be about their experiences leading up to their decision to major in physics. I will be randomly selecting interested students from ten different universities to participate in these interviews. This project has been approved by the Human Subject Institutional Review Board at Western Michigan University. Confidentiality issues have been addressed. I would appreciate a list of physics majors and their university/college assigned email addresses from your university/college. I will send them an email inviting them to participate in this study. Please feel free to email or phone me if you have any questions or concerns.

Name, major field of study, and university assigned email addresses are designated as directory information at Western Michigan University. Directory information can be disclosed by the University/College without the consent of the student according to the Family Educational Rights and Privacy Act (FERPA) of 1974. Please check with your Registrar Office to make sure that your University/College designates this information as directory information.

Sincerely,

Donya Dobbin

269-806-2559

donya.dobbin@wmich.edu

Appendix D

Invitation Email to Student for Phase One

Subject Line: Participate in a Research Study and Earn a Free Large Pizza

Dear _______

My name is Donya Dobbin. I am a PhD student in Physics Education at Western Michigan University working on my dissertation project. This study is part of my dissertation project and will only include physics majors. The purpose of this study is to determine common and influencing experiences of physics majors. If you decide to participate, all you need to do is answers questions using email. There will be a maximum of four emails to which you will have to respond. After the four emails are complete, you will be sent a gift card for a free large pizza. Your answers will be kept confidential. If you have any questions please feel free to email or call me with them. Please respond to this email if you would like to learn more about participating.

Thanks Donya

269-806-2559

donya.dobbin@wmich.edu

Appendix E

Consent Document for Phase One

Subject Line: Consent Form

Consent Form for Experience that Influence a Student's Choice on Majoring in Physics

Western Michigan University

Mallinson Institute for Science Education

Principal Investigator: Charles Henderson, PhD
Student Investigator: Donya Dobbin

You have been invited to participate in a research project entitled "Experience that Influence a Student's Choice on Majoring in Physics." This research is intended to study the reasons and experiences that influence students who choose to major in physics. This is the student investigator's research study that will be used as her dissertation.

You will be asked to participate in an interview that will be conducted using email. There will be four email messages sent to you that contain interview questions. It will take you approximately 30 minutes to answer each of these email messages. There will be a fifteen dollar gift card provided for your participation after you have completed all of the interview processes. The cost to you is the amount of time it takes for you to participate in the study. Your participation in this study may allow you to explore your thoughts and feelings about your reasons for choosing physics as a major.

As in all research, there may be unforeseen risks to the participant. All of the information collected from you is confidential. That means that your name will not appear on any papers on which this information is recorded. Consent emails and printed copies of the interview will be retained for the duration of the project locked in the principal investigator's office and destroyed after 3 years. The emails will be destroyed after the information is moved into a Word document.

You may refuse to participate or quit at any time during the study without prejudice or penalty. To do so, you may email either researcher and let them know that you no longer wish to participate in the study. If you do not respond to an email in one week, you will be sent a reminder email by the researcher. If you do not respond to the reminder email, this will also be taken as a sign that you wish to end your participation and you will no longer be sent emails by the researcher. If you have any questions or concerns about this study, you may contact, either Charles Henderson at charles.henderson@wmich.edu or Donya Dobbin at donya.dobbin@wmich.edu or 269-806-2559. You may also contact the Chair, Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) if questions or problems arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB). Your email response indicates that you have read the purpose and requirements of the study and that you agree to participate. Please reply to this email and mark the appropriate box. Thanks Donya 269-806-2559

☐ Agree

☐ Do Not Agree

Appendix F

Interview Protocol for Phase One

Instructions:
Please answer all questions as thoroughly as possible. Do not worry about correcting your spelling or grammar. There are no wrong answers so answer as honestly and completely as possible. Please return your answers within one week. Thank you for your time. Donya Dobbin

What grade were you in when you decided to major in physics in college?

Why did you choose to major in physics?

Are you receiving a degree in physics so that you can teach at the high school or middle school level?

Subject
What science classes did you take in high school and middle school? What topics did they cover? What type of mathematics did they use?

Why did you choose to take the amount of science and math classes in high school that you did?

What grade were you in when you first thought about pursuing a career in physics? What occurred that made you think of this as a possible career?

How would you describe physics as a subject? (for example: easy, challenging, practical, ...)

End of first email

Instructions:
Please answer all questions as thoroughly as possible. Do not worry about correcting your spelling or grammar. There are no wrong answers so answer as honestly and completely as possible. Please return your answers in one week. Thank you for your time. Donya Dobbin

Teachers
How would you describe the determination of the grades in your high school physics class? Did everyone get a good grade? Was it easy to get an A? What were the grades in the class based upon?

How would you describe the personality and approachability of your high school physics teacher?

What was a typical day in your high school physics class?

Was there a unique occurrence in your physics class that you remember clearly?

Influential Adults
Name two or three adults that were most influential in your upbringing and with which you spent a significant amount of time?

Describe your relationship with these adults?

What was their occupation and educational background?

What would you consider as your their hobbies?

What did they expect from you while you were attending junior high and high school? (for example: grades, responsibilities, class choices ...)
End of second email with followup questions

Instructions:
Please answer all questions as thoroughly as possible. Do not worry about correcting your spelling or grammar. There are no wrong answers so answer as honestly and completely as possible. Please return your answers in one week. Thank you for your time. Donya Dobbin

Self
What tv shows or type of shows did you regularly watch in junior high and high school? What did you like about these shows?

What hobbies did you have in junior high and high school that you spent a lot of time at? What did you like about these hobbies?

How did you view your math and science classes in junior high and high school? (for example: easy, challenging, boring...)

Peers
If you were identified as being part of a "clique" in school, which "clique" would that be?

How would you describe your "dating" life while you were in high school? When did you start dating?

Did your friends discourage or encourage you to take science classes? Can you give an example of a situation that occurred that made you feel like they were discouraging or encouraging you?

Personal Description
What is your age and ethnicity?

Is there anything that you feel should be added that we have not discussed yet that may have influenced your choice of major?
End of third email and followup questions

Fourth email (if necessary) with followup questions

Closing email

Thank you for participating in this study. If you have any questions about the study or wish follow-up information, just let me know. Please email me the address at which you want your $20 gift card sent. Thanks again. Donya Dobbin

Appendix G

Invitation Email to Students for Phase Two

Subject Line: Participate in a Research Study and Earn a $10 gift card

Dear _______

My name is Donya Dobbin. I am a PhD student in Physics Education at Western Michigan University working on my dissertation project. I would like you to participate in a study of physics majors. The purpose of this study is to determine common and influencing experiences of physics majors. If you decide to participate, all you need to do is answers questions using email. There will be a maximum of two emails to which you will be asked to respond. After the two emails are complete, you will be sent a $10 gift card to your choice of Pizza Hut, Barnes and Nobles, or Target. Your answers will be kept confidential. If you have any questions please feel free to email or call me with them. Please respond to this email if you would like to learn more about participating.

Thanks Donya

269-806-2559

donya.dobbin@wmich.edu

Appendix H

Consent Document for Phase Two

Subject Line: Consent Form

Consent Form for Experience that Influence a Student's Choice on Majoring in Physics-Phase 2

Western Michigan University

Mallinson Institute for Science Education

Principal Investigator: Charles Henderson, PhD
Student Investigator: Donya Dobbin

You have been invited to participate in a research project entitled "Experience that Influence a Student's Choice on Majoring in Physics-Phase 2." This research is intended to study the reasons and experiences that influence students who choose to major in physics. This is the student investigator's research study that will be used as her dissertation.

You will be asked to participate in an interview that will be conducted using email. There will be two email messages sent to you that contain interview questions. It will take you approximately 30 minutes to answer each of these email messages. There will be a ten dollar gift card provided for your participation after you have completed all of the interview processes. The cost to you is the amount of time it takes for you to participate in the study. Your participation in this study may allow you to explore your thoughts and feelings about your reasons for choosing physics as a major.

As in all research, there may be unforeseen risks to the participant. All of the information collected from you will be treated confidentially. That means that your name will not appear on any papers on which this information is recorded. Consent emails and printed copies of the interview will be retained for the duration of the project locked in the principal investigator's office and destroyed after 3 years. The emails will be destroyed after the information is moved into a Word document.

You may refuse to participate or quit at any time during the study without prejudice or penalty. To do so, you may email either researcher and let them know that you no longer wish to participate in the study. If you do not respond to an email in one week, you will be sent a reminder email by the researcher. If you do not respond to the reminder email, this will also be taken as a sign that you wish to end your participation and you will no longer be sent emails by the researcher. If you have any questions or concerns about this study, you may contact, either Charles Henderson at charles.henderson@wmich.edu or Donya Dobbin at donya.dobbin@wmich.edu or 269-806-2559. You may also contact the Chair, Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) if questions or problems arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB). Your email response indicates that you have read the purpose and requirements of the study and that you agree to participate. Please reply to this email and mark the appropriate box. Thanks Donya 269-806-2559

☐ Agree

☐ Do Not Agree

Appendix I

Interview Protocol for Phase Two

Instructions:

Please answer all questions as thoroughly as possible. Do not worry about correcting your spelling or grammar. There are no wrong answers so answer as honestly and completely as possible. Please return your answers within one week. Thank you for your time. Donya Dobbin

1) What is the earliest that you can remember becoming interested in physics? What experience caused this interest?

2) When did you seriously consider majoring in physics in college? What other college majors did you seriously consider? What caused you to become confident in your choice to major in physics?

3) Did you receive any encouragement to become a physics major? If so, from whom?

Did you receive any encouragement to major in a science field in general? If so, from whom?

What did this encouragement look like?

4) Were you concerned about your career prospects as a physics major? If no, why were you not concerned? If yes, what were your concerns?

5) Have you worked with a physics professor on a project in college? How did this influence your decision to major in physics?

6) How would you describe the personality of and your relationship with your high school physics teacher? Did his/her personality and relationship effect your impression of the physics subject?

7) Name two or three adults that were most influential in your upbringing and with which you spent a significant amount of time. What were your influential adults' occupations? What was your exposure to and familiarity with their occupations (e.g., did they often talk about work? How often did you visit their workplace? Etc.)

8) What is your gender and ethnicity?

9) What are your career plans?

Second email (if necessary) with followup questions

Appendix J

Strength Table for Phase One

Subject	**Gender**	Male	Female	**Reasons**	Interesting	Books	Toys	Ability	Career	Encouraged	**Decision**	Before	During College	Time Off	**More Math**	Req/Encourage	Good	Required	College	Concrete	Outside
MSU02			X									X				X		X		X	
MSU05		X			X							X					X				
MSU08			X		X							X				X		X	X		
MSU09		X										X				X	X	X			
MSU11			X			X						X					X				
MSU12		X														X		X			
MSU14		X		X	X	X							X			X			X		
MSU15		X			X		X						X			X		X			
MT01		X										X								X	
MT04		X			X	X							X			X	X	X			
MT05		X			X		X		X	X		X					X				
MT07			X			X			X			X				X	X	X			
MT08		X			X								X			X		X			
MT09		X			X			X				X				X			X		
MT10			X		X	X						X				X			X		
W1		X				X								X							
W2		X				X							X			X			X		
W3			X									X					X				
W4		X				X						X									
W5			X			X	X	X		X			X			X		X			
W7		X												X		X			X		
WMU01		X				X							X				X				
WMU02			X													X		X			
WMU04			X		X							X					X				
WMU06			X		X				X	X		X				X		X	X		
WMU08			X			X	X					X									
WMU09		X							X					X			X				
WMU11		X				X				X			X			X		X			
WMU12			X			X		X	X					X			X				
WMU13		X										X					X				
Hope1		X			X							X				X		X	X		
Hope2			X				X						X								X
KColl1		X			X								X				X			X	
KColl2		X											X				X				
KColl3		X						X					X								X
Total		22	13	1	13	13	5	4	5	4		17	12	4		18	14	13	8	3	2

Subject	**Initial Interest**	Challenging	Practical	Interesting	Do Anything	Math	**Typical Day**	Lecture	Problems	**Occurrence**	Projects	Speakers	**Labs**	No Statement	Monthly	Daily	Weekly	**HS Personality**	Funny	Energy	Ind. Help	Not Appl	Laid back	Interactive	Practical
MSU02		X			X			X			X						X					X			
MSU05		X			X			X	X		X				X						X				
MSU08		X									X				X				X		X				
MSU09		X	X						X		X						X			X		X			
MSU11		X						X			X			X						X					
MSU12				X				X							X				X		X				
MSU14		X	X					X	X						X				X			X			
MSU15								X						X					X						
MT01			X					X	X						X										
MT04		X												X						X					
MT05		X	X								X					X					X				
MT07		X	X			X		X	X						X					X	X				
MT08			X											X											
MT09		X						X						X					X						
MT10		X			X									X								X			
W1		X												X											
W2		X	X			X		X			X				X				X		X				
W3		X		X		X		X								X				X					
W4				X				X			X					X									
W5		X						X			X				X				X						
W7		X	X					X							X						X				
WMU01		X	X											X							X				
WMU02		X		X										X											
WMU04		X	X												X						X				
WMU06		X	X					X				X		X						X	X				
WMU08		X				X		X			X			X						X	X				
WMU09					X			X						X											
WMU11		X		X										X						X					
WMU12									X					X							X				
WMU13		X	X					X									X				X				
Hope1		X						X								X						X			
Hope2		X						X			X	X		X											
KColl1		X	X												X				X						
KColl2		X						X			X					X			X		X				
KColl3			X					X			X					X				X	X				
Total		27	14	5	4	4		22	6		13	2		15	11	6	3		9	9	15	5	0	0	0

Subject	**College**	One Adults	Two Adults	**Expectations**	Grades	No Control	College	**Careers**	Both	Bio. Sc.	Phy. Sc.	Phy. Based	Teacher	Money	Computers	Stay home	Sales	Office	Artistic	Police	Owner	Social	Lawyer
MSU02					X		X		X	X													
MSU05		X	X		X		X																
MSU08		X				X								X			X						
MSU09		X			X		X		X	X	X												
MSU11					X							X											
MSU12		X	X		X	X			X	X													
MSU14		X	X		X		X		X	X				X									
MSU15		X			X	X																	X
MT01					X									X	X								
MT04		X			X	X			X		X												
MT05						X								X							X		
MT07					X				X		X									X			
MT08		X							X		X												
MT09					X							X					X						
MT10		X	X		X	X			X		X												
W1		X				X			X		X												
W2		X			X																		
W3		X			X				X	X										X			
W4		X							X		X	X											
W5		X			X	X			X		X												
W7		X	X		X		X		X	X												X	
WMU01		X			X	X									X								
WMU02					X															X			
WMU04		X			X	X						X					X						
WMU06					X		X																
WMU08						X																	
WMU09		X	X			X																	
WMU11		X	X		X																		
WMU12					X							X											
WMU13		X	X		X				X	X	X	X											
Hope1		X	X		X								X		X	X							
Hope2		X	X														X						
KColl1					X		X		X	X													
KColl2		X	X		X	X	X		X		X												
KColl3		X			X	X	X		X	X							X						
Total		24	11		27	14	9		17	9	10	6	1	4	3	1	5	0	0	3	1	1	1

Subject	**TV Shows**	None	Comedy	Education	Science	Plot	Cartoons	**Hobbies**	Sports	Reading	Music	Video games	Internet	**Views math**	Easy	Interesting	Difficult	Boring	**Friends**	Neither	Same	Encouraging	**Dating**	Limited	None	Several
MSU02						X					X				X						X				X	
MSU05		X								X	X	X			X						X				X	
MSU08		X									X							X						X		
MSU09		X									X									X				X		
MSU11									X												X					X
MSU12				X																X				X		
MSU14						X				X					X					X	X			X		
MSU15															X									X		
MT01																				X				X		
MT04		X							X	X		X								X		X				X
MT05			X	X								X	X		X									X		
MT07		X							X	X					X							X			X	
MT08		X									X							X							X	
MT09					X				X		X				X						X			X		
MT10				X						X		X			X						X			X		
W1		X											X		X						X					X
W2				X					X	X						X					X			X		
W3				X						X						X				X					X	
W4			X			X					X				X	X						X				X
W5			X								X											X		X		
W7			X							X		X					X	X		X				X		
WMU01				X					X						X					X					X	
WMU02			X						X	X							X									
WMU04					X				X						X					X				X		
WMU06									X	X							X									X
WMU08						X																X		X		
WMU09					X								X			X		X		X				X		
WMU11					X	X				X		X					X			X					X	
WMU12			X		X						X				X	X				X		X		X		
WMU13							X		X		X	X			X						X			X		
Hope1		X	X				X			X		X			X	X								X		
Hope2					X						X				X									X		
KColl1			X						X						X						X					X
KColl2			X			X	X		X			X			X	X				X				X		
KColl3		X					X		X	X							X	X		X	X	X		X		
Total		9	9	6	6	6	4		13	13	11	9	3		18	7	3	5		14	11	7		21	7	6

Subject	**Cliques**	None	Variety	Smart	Music
MSU02				X	X
MSU05			X		
MSU08				X	
MSU09		X			
MSU11			X		
MSU12				X	
MSU14		X			
MSU15					
MT01				X	
MT04			X		
MT05		X			
MT07			X		
MT08		X			
MT09					X
MT10					
W1		X			
W2				X	
W3		X			
W4			X		
W5				X	
W7					X
WMU01					
WMU02					
WMU04				X	
WMU06		X			
WMU08		X			
WMU09		X			X
WMU11		X			
WMU12			X		X
WMU13					X
Hope1			X		
Hope2		X		X	
KColl1			X		
KColl2			X		
KColl3		X	X		
Total		12	10	8	6

Appendix K

Strength Table for Phase Two

Subjects	**Gender**	Male	Female	**Reasons**	Interesting	Books	Toys	Ability	Career	Encouraged	**Initial**	Interesting	Teachers	Hands-on	Astronomy	Books	Ability	Encouraged	Structure	Math
Butler 1			X							X					X					
DePaul 1		X								X										
DePaul 3		X							X								X			
DePaul 4		X														X				
Eastern IL 1		X						X								X	X			
Eastern IL 3			X					X				X								
Eastern IL 4		X																		
Goshen 1			X																	
Goshen 2		X											X							
Goshen 5		X			X							X								
Goshen 6			X												X			X		
ISU 1		X						X					X				X			
IU Bloomington 1			X		X			X					X		X					
IU Bloomington 2			X						X			X								
IU Bloomington 3		X			X											X		X		
IU Bloomington 4		X																		
IU Bloomington 5		X			X							X	X							
IU Bloomington 8			X		X							X								
IU Bloomington 9		X															X			
IU Bloomington 10		X			X															
IU PU FW 1		X							X			X								
IU PU FW 2		X								X										
IU PU FW 3		X								X										
IU PU FW 4		X															X			
IU PU FW 5		X											X	X						
IU South Bend 1		X								X		X					X			X
IU South Bend 3		X											X	X						
IU South Bend 5		X																		
IU South Bend 8		X											X							
IU South Bend 9		X							X											
Kenyon 1		X			X									X						
Kenyon 2		X			X															
Kenyon 3			X		X											X				
Kenyon 4			X									X		X	X					
Kenyon 5		X			X							X							X	
Kenyon 6			X					X				X	X		X					
Knox 1			X							X		X							X	
Knox 2		X						X				X								
Loyola 1		X										X								
Loyola 2			X		X							X		X						
Loyola 3		X							X											
Loyola 5			X						X						X					
Loyola 6		X						X	X											
Sub Total		30	13		11	0	0	7	7	6		14	8	5	6	4	6	0	2	1

Subjects	**Gender**	Male	Female	**Choosing**	Interesting	Books	Toys	Ability	Career	Encour.	**Initial**	Interesting	Teachers	Hands-on	Astronomy	Books	Ability	Encouraged	Structure	Math
Loyola 7		X							X											
Loyola 8			X		X							X								
Loyola 9			X																	
Loyola 10		X			X							X								
Maimi 1		X								X		X								
Maimi 2			X																	
Maimi 3			X		X								X							
Maimi 4		X														X				
Maimi 5			X									X	X							
Maimi 7		X						X						X						
Maimi 9		X						X				X								
Marietta 1			X																	
Marietta 2		X														X	X			
Northeastern 1			X											X						
Northeastern 2		X							X				X							
Northwestern 1			X									X								
Northwestern 2			X									X					X			
Northwestern 3			X		X					X										
Northwestern 5			X									X				X				
Northwestern 7		X										X								
Northwestern 8		X			X										X	X				
Northwestern 9		X													X					
Northwestern 11		X											X				X			
Northwestern 12		X											X							
Ohio 1		X											X	X						
Ohio 2		X			X											X				
Ohio Northern 1		X						X						X		X				
Ohio Wesleyan 1		X												X					X	
Ohio Wesleyan 2		X			X										X					X
Ohio Wesleyan 3		X			X									X						
Purdue WL 1		X			X													X		
Purdue WL 2		X													X			X		
Rose-Hulman 1			X		X							X	X							
Valpo 1			X									X						X		
Valpo 2			X		X							X	X		X				X	
Valpo 3			X		X								X							
Valpo 4		X			X									X	X					
Valpo 5		X								X						X				
Valpo 7		X								X		X	X						X	
Wabash 1		X						X				X		X						
Wabash 3		X										X								
Western IL 1		X							X					X						
Western IL 2		X																		
Sub Total		29	15		13	0	0	5	3	4		16	10	9	7	7	3	0	3	1

Subjects	**Gender**	Male	Female	**Choosing**	Interesting	Books	Toys	Ability	Career	Encour.	**Initial**	Interesting	Teachers	Hands-on	Astronomy	Books	Ability	Encouraged	Structure	Math
Wittenberg 1			X		X							X		X						
Wooster 1			X											X						
Wooster 3		X			X											X				
Wooster 4			X		X								X							
Xavier 1			X					X		X					X					
Xavier 2		X															X			
Xavier 3		X			X															X
Sub Total		4	4		4	0	0	1	0	1		1	1	2	1	1	1	0	0	1
Total		63	32		28	0	0	13	10	11		31	19	16	14	12	10	0	5	3

Subjects	**Decision**	Before	During College	Time Off	**HS Personality**	Funny	Energy	Ind. Help	Not App.	Laid back	Interactive	Practical	**HS Effect**	Positive	No Effect	No Comment	Negative	**Careers**	Both	Bio. Sc.	Phy. Sc.	Phy. Based
Butler 1		X				X						X		X					X		X	
DePaul 1			X						X								X					
DePaul 3		X														X						
DePaul 4									X						X							
Eastern IL 1			X																X	X		X
Eastern IL 3																			X	X		
Eastern IL 4		X														X			X	X		
Goshen 1						X						X		X					X		X	
Goshen 2		X				X										X						
Goshen 5		X													X				X	X	X	
Goshen 6		X													X							
ISU 1				X							X					X						
IU Bloomington 1		X				X								X								
IU Bloomington 2									X								X		X		X	
IU Bloomington 3		X					X									X			X	X		
IU Bloomington 4		X							X								X					
IU Bloomington 5			X			X								X								
IU Bloomington 8			X			X									X							
IU Bloomington 9		X				X								X					X		X	
IU Bloomington 10			X													X						X
IU PU FW 1			X			X		X						X								X
IU PU FW 2			X									X				X						X
IU PU FW 3			X			X					X			X					X		X	
IU PU FW 4				X		X					X			X								X
IU PU FW 5			X						X						X							
IU South Bend 1			X											X					X		X	
IU South Bend 3		X				X								X								X
IU South Bend 5		X																				
IU South Bend 8				X		X	X							X								X
IU South Bend 9			X												X							
Kenyon 1		X					X							X								
Kenyon 2			X						X						X							
Kenyon 3			X			X			X						X				X	X	X	
Kenyon 4				X								X		X								
Kenyon 5			X						X								X		X	X	X	
Kenyon 6			X			X	X							X					X	X		
Knox 1		X				X	X							X								X
Knox 2		X				X	X							X					X	X		X
Loyola 1		X				X	X	X						X								
Loyola 2		X						X								X			X	X		X
Loyola 3			X						X						X				X		X	
Loyola 5			X				X							X					X	X	X	
Loyola 6			X			X										X						X
Sub Total		17	18	4		18	8	3	9	0	3	4		18	9	9	4		18	11	11	11

Subjects	**Decision**	Before	During College	Time Off	**HS Personality**	Funny	Energy	Ind. Help	Not App.	Laid back	Interactive	Practical	**HS Effect**	Positive	No Effect	No Comm	Negative	**Careers**	Both	Bio. Sc.	Phy. Sc.	Phy. Based
Loyola 7				X												X						X
Loyola 8			X												X				X		X	
Loyola 9			X																X	X		
Loyola 10			X			X	X	X						X								
Maimi 1		X				X	X							X								
Maimi 2			X						X						X							
Maimi 3				X		X								X								
Maimi 4				X											X							
Maimi 5						X	X							X								
Maimi 7		X							X						X				X		X	X
Maimi 9			X																			
Marietta 1		X																	X		X	
Marietta 2			X													X						
Northeastern 1			X				X	X						X								X
Northeastern 2		X												X								
Northwestern 1			X			X	X							X					X	X		
Northwestern 2		X							X							X			X		X	
Northwestern 3			X												X				X	X		
Northwestern 5			X						X								X		X	X		
Northwestern 7		X													X							
Northwestern 8		X							X						X				X	X		
Northwestern 9			X			X	X							X					X	X	X	
Northwestern 11		X				X		X						X					X		X	
Northwestern 12		X				X								X					X	X		
Ohio 1			X			X						X		X								
Ohio 2		X				X	X							X					X		X	
Ohio Northern 1		X												X								
Ohio Wesleyan 1			X			X								X								
Ohio Wesleyan 2			X						X						X							X
Ohio Wesleyan 3			X				X							X								
Purdue WL 1		X							X								X					
Purdue WL 2		X								X	X					X			X	X		
Rose-Hulman 1									X								X		X		X	
Valpo 1		X				X								X					X		X	
Valpo 2		X														X						X
Valpo 3		X				X	X	X						X								
Valpo 4		X								X					X				X	X		X
Valpo 5		X						X						X								X
Valpo 7		X				X	X							X								
Wabash 1		X					X			X	X			X					X	X		
Wabash 3			X			X								X								X
Western IL 1		X				X								X					X	X		
Western IL 2		X													X							X
Sub Total		22	16	3		16	11	5	8	3	2	1		22	10	5	3		19	11	9	9

Subjects	**Decision**	Before	During College	Time Off	**HS Personality**	Funny	Energy	Ind. Help	Not App.	Laid back	Interactive	Practical	**HS Effect**	Positive	No Effect	No Comm	Negative	**Careers**	Both	Bio. Sc.	Phy. Sc.	Phy. Based
Wittenberg 1						X	X	X						X					X	X		
Wooster 1			X			X								X								
Wooster 3			X				X							X								
Wooster 4			X			X								X					X	X		
Xavier 1							X	X						X					X	X		X
Xavier 2			X						X							X			X		X	X
Xavier 3		X														X			X			
Sub Total		1	4			3	3	2	1	0	0	0		5	0	2	0		5	3	1	2
Total		40	38	7		37	22	10	18	3	5	5		45	19	16	7		42	25	21	22

Subjects	Teacher	Money	Computers	Stay home	Sales	Office	Artistic	Police	Owner	Social	Lawyer	**Encouragement**	yes	No	**Who**	Parents	Teacher	Professor	Majors	Department
Butler 1	X						X						X				X			
DePaul 1		X											X							
DePaul 3	X									X				X						
DePaul 4													X				X			
Eastern IL 1													X			X		X		X
Eastern IL 3		X											X							
Eastern IL 4						X		X					X				X			
Goshen 1													X				X		X	
Goshen 2	X												X			X				
Goshen 5														X						
Goshen 6			X								X		X			X				
ISU 1													X				X			
IU Bloomington 1			X										X							
IU Bloomington 2														X						
IU Bloomington 3		X											X			X	X			
IU Bloomington 4		X				X								X						
IU Bloomington 5			X											X						
IU Bloomington 8	X												X			X				
IU Bloomington 9							X						X							
IU Bloomington 10	X												X				X			
IU PU FW 1	X												X					X	X	
IU PU FW 2	X												X					X		
IU PU FW 3						X							X						X	
IU PU FW 4					X									X						
IU PU FW 5					X									X						
IU South Bend 1	X												X							
IU South Bend 3		X												X						
IU South Bend 5	X						X						X			X				
IU South Bend 8							X							X						
IU South Bend 9	X		X					X					X			X				
Kenyon 1		X											X				X			
Kenyon 2		X								X				X						
Kenyon 3													X			X				
Kenyon 4											X		X			X				
Kenyon 5													X					X		
Kenyon 6													X			X				
Knox 1													X				X	X	X	
Knox 2							X						X			X				X
Loyola 1													X					X		
Loyola 2								X					X				X	X		
Loyola 3													X			X				
Loyola 5													X			X				
Loyola 6	X		X										X			X				
Sub Total	11	7	5	0	2	3	5	3	0	2	2		33	10		14	10	7	4	2

Subjects	Teacher	Money	Computers	Stay home	Sales	Office	Artistic	Police	Owner	Social	Lawyer	**Encouragemen**	yes	No	**Who**	Parents	Teacher	Professor	Majors	Department
Loyola 7														X						
Loyola 8	X								X				X					X		
Loyola 9									X					X						
Loyola 10													X			X				
Maimi 1											X		X				X			
Maimi 2				X										X						
Maimi 3													X			X				
Maimi 4														X						
Maimi 5						X			X				X			X	X			
Maimi 7														X						
Maimi 9													X					X		
Marietta 1													X							
Marietta 2				X									X				X		X	
Northeastern 1													X			X		X		
Northeastern 2													X			X	X			
Northwestern 1				X										X						
Northwestern 2														X						
Northwestern 3		X												X						
Northwestern 5				X										X						
Northwestern 7	X													X						
Northwestern 8														X						
Northwestern 9													X			X				
Northwestern 11	X												X				X			
Northwestern 12				X									X				X			
Ohio 1				X				X					X				X			
Ohio 2													X							
Ohio Northern 1			X	X										X						
Ohio Wesleyan 1						X								X						
Ohio Wesleyan 2					X								X			X				
Ohio Wesleyan 3							X						X						X	
Purdue WL 1	X												X			X				
Purdue WL 2														X						
Rose-Hulman 1							X						X		X	X			X	
Valpo 1													X		X	X				
Valpo 2						X								X						
Valpo 3	X		X										X		X	X	X			
Valpo 4													X			X				
Valpo 5						X							X			X				
Valpo 7						X							X				X			
Wabash 1													X							X
Wabash 3				X										X						
Western IL 1									X				X		X	X				
Western IL 2			X											X						
Sub Total	5	1	3	9	1	5	2	1	4	0	1		26	18	4	14	9	3	3	1

Subjects	Teacher	Money	Computers	Stay home	Sales	Office	Artistic	Police	Owner	Social	Lawyer	**Encouragement**	yes	No	**Who**	Parents	Teacher	Professor	Majors	Department
Wittenberg 1													X					X		
Wooster 1	X												X						X	
Wooster 3	X		X											X						
Wooster 4										X			X			X				
Xavier 1					X								X			X				
Xavier 2														X						
Xavier 3	X	X												X						
Sub Total	3	1	1	0	1	0	0	0	0	1	0		4	3		2	0	1	1	0
Total	19	9	9	9	4	8	7	4	4	3	3		63	31	4	30	19	11	8	3

Subjects	**Type**	Reinforcement	General	Information	**Future**	Physics	No Theme	Engineer	Astronomy	Medical	Don't Know	**Research**	No Research	Positive	No Comment	No Effect	Negative
Butler 1									X				X				
DePaul 1						X							X				
DePaul 3							X										
DePaul 4		X								X			X				
Eastern IL 1			X			X											
Eastern IL 3		X							X				X				
Eastern IL 4		X		X		X									X		
Goshen 1			X	X		X							X				
Goshen 2			X					X							X		
Goshen 5						X											
Goshen 6									X					X			
ISU 1			X						X						X		
IU Bloomington 1			X						X				X				
IU Bloomington 2										X							
IU Bloomington 3		X		X		X								X			
IU Bloomington 4							X						X				
IU Bloomington 5						X							X				
IU Bloomington 8				X		X							X				
IU Bloomington 9				X				X					X				
IU Bloomington 10						X							X				
IU PU FW 1			X			X								X			
IU PU FW 2		X					X								X		
IU PU FW 3		X									X		X				
IU PU FW 4						X								X			
IU PU FW 5						X							X				
IU South Bend 1		X				X							X				
IU South Bend 3						X											
IU South Bend 5			X			X							X				
IU South Bend 8											X		X				
IU South Bend 9		X						X					X				
Kenyon 1		X									X		X				
Kenyon 2						X							X				
Kenyon 3				X		X							X				
Kenyon 4				X		X							X				
Kenyon 5										X			X				
Kenyon 6			X								X		X				
Knox 1			X					X					X				
Knox 2		X				X							X				
Loyola 1		X									X		X				
Loyola 2		X								X				X			
Loyola 3				X				X							X		
Loyola 5			X			X											
Loyola 6				X							X					X	
Sub Total		12	10	9		20	3	5	5	4	6		26	5	5	1	0

Subjects	Type	Reinforcement	General	Information	Future	Physics	No Theme	Engineer	Astronomy	Medical	Don't Know	Research	No Research	Positive	No Comment	No Effect	Negative
Loyola 7						X							X				
Loyola 8		X						X									
Loyola 9										X				X			
Loyola 10		X								X				X			
Maimi 1						X										X	
Maimi 2							X						X				
Maimi 3			X				X						X				
Maimi 4						X							X				
Maimi 5			X	X		X									X		
Maimi 7						X							X				
Maimi 9				X		X											
Marietta 1				X		X							X				
Marietta 2		X	X			X							X				
Northeastern 1		X				X							X				
Northeastern 2			X							X			X				
Northwestern 1						X										X	
Northwestern 2						X								X			
Northwestern 3									X					X			
Northwestern 5							X						X				
Northwestern 7						X							X				
Northwestern 8							X							X			
Northwestern 9		X				X										X	
Northwestern 11		X				X								X			
Northwestern 12				X		X											
Ohio 1											X		X				
Ohio 2						X								X			
Ohio Northern 1							X										X
Ohio Wesleyan 1							X							X			
Ohio Wesleyan 2				X				X								X	
Ohio Wesleyan 3		X				X							X				
Purdue WL 1				X			X										X
Purdue WL 2										X			X				
Rose-Hulman 1		X		X		X								X			
Valpo 1			X			X							X				
Valpo 2									X				X				
Valpo 3				X		X							X				
Valpo 4		X									X		X				
Valpo 5			X	X					X								X
Valpo 7		X					X						X				
Wabash 1								X									
Wabash 3						X										X	
Western IL 1				X			X						X				
Western IL 2							X						X				
Sub Total		10	6	10		22	10	3	3	4	2		21	9	1	5	3

Subjects	**Type**	Reinforcement	General	Information	**Future**	Physics	No Theme	Engineer	Astronomy	Medical	Don't Know	**Research**	No Research	Positive	No Comment	No Effect	Negative
Wittenberg 1		X					X						X				
Wooster 1						X								X	X		
Wooster 3						X							X				
Wooster 4			X					X					X				
Xavier 1			X						X				X				
Xavier 2						X							X				
Xavier 3								X								X	
Sub Total		1	2	0		3	1	2	1	0	0		5	1	1	1	0
Total		23	18	19		45	14	10	9	8	8		52	15	7	7	3

Subjects	**Other**	Math	Engineer	Chemistry	Art	Biology	Computer	W Languages	Psychology	None
Butler 1										
DePaul 1		X								
DePaul 3		X					X			
DePaul 4										
Eastern IL 1					X					
Eastern IL 3					X					
Eastern IL 4										
Goshen 1				X						
Goshen 2		X			X			X		
Goshen 5		X								X
Goshen 6										
ISU 1			X							
IU Bloomington 1										
IU Bloomington 2										
IU Bloomington 3										X
IU Bloomington 4										X
IU Bloomington 5		X								
IU Bloomington 8									X	
IU Bloomington 9										
IU Bloomington 10		X								
IU PU FW 1										
IU PU FW 2										
IU PU FW 3			X							
IU PU FW 4										
IU PU FW 5										
IU South Bend 1							X			
IU South Bend 3										
IU South Bend 5										X
IU South Bend 8										
IU South Bend 9			X				X			
Kenyon 1		X								
Kenyon 2										
Kenyon 3								X		
Kenyon 4		X						X		
Kenyon 5				X						
Kenyon 6					X					
Knox 1			X							
Knox 2										
Loyola 1				X						
Loyola 2									X	
Loyola 3						X				
Loyola 5						X				
Loyola 6										
Sub Total		8	4	3	4	2	3	3	2	4

Subjects	**Other**	Math	Engineer	Chemistry	Art	Biology	Computer	W Language	Psychology	None
Loyola 7			X							
Loyola 8										
Loyola 9		X		X						
Loyola 10						X				
Maimi 1										
Maimi 2										
Maimi 3										
Maimi 4							X			X
Maimi 5				X						
Maimi 7				X						
Maimi 9										
Marietta 1										
Marietta 2		X	X	X						
Northeastern 1						X				
Northeastern 2										
Northwestern 1										
Northwestern 2										
Northwestern 3					X					
Northwestern 5					X					
Northwestern 7										
Northwestern 8					X					
Northwestern 9			X							
Northwestern 11		X			X					
Northwestern 12										
Ohio 1			X	X						
Ohio 2		X								
Ohio Northern 1				X						
Ohio Wesleyan 1		X								
Ohio Wesleyan 2		X	X							
Ohio Wesleyan 3				X						
Purdue WL 1					X					
Purdue WL 2				X						
Rose-Hulman 1			X							
Valpo 1										
Valpo 2								X		
Valpo 3										
Valpo 4										
Valpo 5										
Valpo 7										
Wabash 1										
Wabash 3			X							
Western IL 1				X						
Western IL 2										
Sub Total		6	7	9	5	2	1	1	0	1

Subjects	**Other**	Math	Engineer	Chemistry	Art	Biology	Computer	W Language	Psychology	None
Wittenberg 1						X			X	
Wooster 1						X				
Wooster 3			X							
Wooster 4		X	X							
Xavier 1								X		
Xavier 2										
Xavier 3			X							
Sub Total		1	3	0	0	2	0	1	1	0
Total		15	14	12	9	6	4	5	3	5