CORRELATES OF GENDER AND ACHIEVEMENT IN
INTRODUCTORY ALGEBRA BASED PHYSICS

A THESIS IN
Physics

Presented to the Faculty of the University of Missouri-Kansas City in partial fulfillment of the requirements for the degree
MASTER OF SCIENCE

by
RACHEL CLARA SMITH

B.A. Physics, University of Missouri-Kansas City, 2009

Kansas City, Missouri
2013
CORRELATES OF GENDER AND ACHIEVEMENT IN INTRODUCTORY ALGEBRA BASED PHYSICS

Rachel Clara Smith, Candidate for the Master of Science Degree
University of Missouri-Kansas City, 2013

ABSTRACT

The field of physics is heavily male dominated in America. Thus, half of the population of our country is underrepresented and underserved. The identification of factors that contribute to gender disparity in physics is necessary for educators to address the individual needs of students, and, in particular, the separate and specific needs of female students. In an effort to determine if any correlations could be established or strengthened between sex, gender identity, social network, algebra skill, scientific reasoning ability, and/or student attitude, a study was performed on a group of 82 students in an introductory algebra based physics course. The subjects each filled out a survey at the beginning of the semester of their first semester of algebra based physics. They filled out another survey at the end of that same semester. These surveys included physics content pretests and posttests, as well as questions about the students’ habits, attitudes, and social networks. Correlates of posttest score were identified, in order of significance, as pretest score, emphasis on conceptual learning, preference for male
friends, number of siblings (negatively correlated), motivation in physics, algebra score, and parents’ combined education level. Number of siblings was also found to negatively correlate with, in order of significance, gender identity, preference for male friends, emphasis on conceptual learning, and motivation in physics. Preference for male friends was found to correlate with, in order of significance, emphasis on conceptual learning, gender identity, and algebra score. Also, gender identity was found to correlate with emphasis on conceptual learning, the strongest predictor of posttest score other than pretest score,
The faculty listed below, appointed by the Dean of the College of Arts and Sciences, have examined a thesis titled, “Correlates of Gender and Achievement in Introductory Algebra Based Physics”, presented by Rachel Clara Smith, candidate for the Master of Science degree, and certify that in their opinion it is worthy of acceptance.

**Supervisory Committee**

Elizabeth Stoddard, Ph.D., Committee Chair
Department of Physics

Robert Riggs, Ph.D.,
Department of Physics

Michael Kruger, Ph.D.,
Department of Physics
## CONTENTS

ABSTRACT ................................................................................................................................. iii

LIST OF TABLES ....................................................................................................................... ix

LIST OF ILLUSTRATIONS ....................................................................................................... xi

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Statement of Problem</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Contributing Factors</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Previously Identified Correlations</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Parents’ Education Level and Achievement</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Number of Siblings and Achievement</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Algebra Ability and Achievement in Physics</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Number of Siblings and Gender</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>..........................................................</td>
</tr>
<tr>
<td>2. METHODOLOGY</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Tests and Surveys</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Sixty Questions Physics Students Should Know</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Mechanics Baseline Test</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Algebra Assessment</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Bem Sex-Role Inventory</td>
<td>..........................................................</td>
</tr>
</tbody>
</table>

vi
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maryland Physics Expectations Survey</td>
<td>15</td>
</tr>
<tr>
<td>Habits and Social Surveys</td>
<td>15</td>
</tr>
<tr>
<td><strong>3. RESULTS AND DISCUSSION</strong></td>
<td>16</td>
</tr>
<tr>
<td>Reliability Analyses</td>
<td>16</td>
</tr>
<tr>
<td>Posttest</td>
<td>17</td>
</tr>
<tr>
<td>Algebra Assessment</td>
<td>18</td>
</tr>
<tr>
<td>Bem Gender Role Survey</td>
<td>19</td>
</tr>
<tr>
<td>Formation of Social, Attitudes, and Habits Variables</td>
<td>22</td>
</tr>
<tr>
<td>Social Factors</td>
<td>23</td>
</tr>
<tr>
<td>Attitudes and Habits Factors</td>
<td>25</td>
</tr>
<tr>
<td>Descriptive Statistics</td>
<td>27</td>
</tr>
<tr>
<td>Analysis and Linear Regressions</td>
<td>30</td>
</tr>
<tr>
<td>Pretest Score as a Predictor of Posttest Score</td>
<td>31</td>
</tr>
<tr>
<td>Conceptual Learning as a Predictor of Posttest Score</td>
<td>33</td>
</tr>
<tr>
<td>Algebra Score as a Predictor of Posttest Score</td>
<td>34</td>
</tr>
<tr>
<td>Number of Siblings as a Predictor of Posttest Score</td>
<td>35</td>
</tr>
<tr>
<td>Combined Parents’ Education Level as a Predictor of Posttest Score</td>
<td>36</td>
</tr>
<tr>
<td>Motivation in Physics as a Predictor of Posttest Score</td>
<td>38</td>
</tr>
<tr>
<td>Preference for Male Friends as a Predictor for Posttest Score</td>
<td>39</td>
</tr>
<tr>
<td>Number of Siblings as a Predictor for Masculinity</td>
<td>42</td>
</tr>
<tr>
<td><strong>4. CONCLUSION</strong></td>
<td>44</td>
</tr>
<tr>
<td>Summary</td>
<td>44</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Item-Total Statistics for Posttest</td>
<td>17</td>
</tr>
<tr>
<td>2. Reliability Statistics for Posttest</td>
<td>18</td>
</tr>
<tr>
<td>3. Item Total Statistics for Algebra Assessment</td>
<td>18</td>
</tr>
<tr>
<td>4. Reliability Statistics for Algebra Assessment</td>
<td>19</td>
</tr>
<tr>
<td>5. Reliability Statistics for Bem Gender Role Survey: Feminine</td>
<td>19</td>
</tr>
<tr>
<td>6. Item-Total Statistics for Bem Gender Role Survey: Feminine</td>
<td>20</td>
</tr>
<tr>
<td>7. Item-Total Statistics for Bem Gender Role Survey: Masculine</td>
<td>21</td>
</tr>
<tr>
<td>8. Reliability Statistics for Bem Gender Role Survey: Masculine</td>
<td>22</td>
</tr>
<tr>
<td>9. Total Variance Explained for Social Factors</td>
<td>24</td>
</tr>
<tr>
<td>10. Rotated Component Matrix for Social Factors</td>
<td>24</td>
</tr>
<tr>
<td>11. Total Variance Explained for Attitudes and Habits Variables</td>
<td>25</td>
</tr>
<tr>
<td>12. Rotated Component Matrix for Attitudes and Habits Variables</td>
<td>26</td>
</tr>
<tr>
<td>13. Descriptives for BSRI Ratio</td>
<td>30</td>
</tr>
<tr>
<td>14. Model Summary for Pretest as a Predictor of Posttest</td>
<td>31</td>
</tr>
<tr>
<td>15. Linear Regression for Pretest as a Predictor of Posttest</td>
<td>31</td>
</tr>
<tr>
<td>16. Model Summary for Conceptual Learning as a Predictor of Posttest</td>
<td>33</td>
</tr>
<tr>
<td>17. Linear Regression for Conceptual Learning as a Predictor of Posttest</td>
<td>33</td>
</tr>
</tbody>
</table>
18. Model Summary for Algebra Score as a Predictor of Posttest .................. 34
19. Linear Regression for Algebra Score as a Predictor of Posttest .................. 34
20. Linear Regression for Number of Siblings as a Predictor of Posttest .......... 35
21. Model Summary for Number of Siblings as a Predictor of Posttest ............ 35
22. Model Summary for Parents Combined Education as a Predictor of Posttest ...... 36
23. Linear Regression for Parents Combined Education as a Predictor of Posttest ... 36
24. Model Summary for Parents Combined Education as a Predictor of Motivation in Physics in Males ................................................................. 37
25. Model Summary for Motivation in Physics as a Predictor of Posttest .......... 38
26. Model Summary for Motivation in Physics as a Predictor of Posttest Score ...... 38
27. Linear Regression for Preference For Male Friends as a Predictor of Posttest .... 39
28. Model Summary for Preference For Male Friends as a Predictor of Posttest ...... 39
29. Linear Regression for Preference For Male Friends as a Predictor of Algebra Score ........................................................................................................ 41
30. Linear Regression for Preference For Male Friends as a Predictor of Conceptual Learning .................................................................................................. 41
31. Linear Regression for Number of Siblings as a Predictor of Masculinity ....... 42
32. Linear Regression for Number of Siblings as a Predictor of Preference for Male Friends........................................................................................................ 42
33. Linear Regression for Masculinity as a Predictor of Preference for Male Friends 43
34. Linear Regression for Masculinity as a Predictor of Conceptual Learning ........ 43
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average Pretest and Posttest with Error Bars</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>2. Feminine and Masculine BSRI Scores for Males and Females</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>3. Mean BSRI Ratio for Males and Females</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>4. Pretest Score as a Predictor of Posttest Score</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>5. Preference for Male Friends as a Predictor of Posttest Score</td>
<td>Error! Bookmark not defined.</td>
</tr>
<tr>
<td>6. Significant Correlates</td>
<td>45</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

First I’d like to thank the members of my committee. I value all that I have learned from them, both in the classroom and beyond. I especially want to thank my advisor, Dr. Elizabeth Stoddard. Throughout the last seven years, she has challenged me to be a better student and to write and think better. She has been an inspiration to me as a woman, as a physicist, and as a friend. I must also thank all of the other teachers who have been influential in my life. I am a better person and a better teacher because of their inspiring example.

I want to thank my wonderful soon-to-be-in-laws, who have done nothing but encourage and support me. I am so honored to be becoming part of their family. I want to thank my five brilliant sisters who have always been a huge source of strength and inspiration to me. I want to thank my loving parents: my mother who is a real source of joy in my life, and Michael who is no longer with us, but whose loving spirit continues to be an inspiration to me and my father and step-mother whose dedication and drive have always set an invaluable example for me.
I also want to thank my amazing friends who truly fuel my spirit. They always are good for a laugh or a shoulder to cry on. I can honestly say that I don’t know what I’d do without them. Last, but by no means least, I want to thank my loving fiancé, Taylor. His unflinching confidence and encouragement, especially as I’ve worked to complete this master’s thesis, has been invaluable. He is the absolute light of my life and I truly can’t imagine how I could have survived the last year without his selfless support.
CHAPTER 1
INTRODUCTION

Statement of Problem

The field of physics remains in strong demand and plays a relatively large role in the promotion and sustenance of economic prosperity due to its contributions to medicine, information technology, communications technology, semiconductor technology, and other applied research-and-development fields (Bureau of Labor Statistics, U.S. Department of Labor 2012). However, due to gender disparity in physics, the field has suffered from the exclusion of the unique and varied perspectives of so many potential female physicists. An increase in the number of women in physics would undoubtedly lead to an increase in quantity of workers, competition for physics related positions, and quality and rate of innovation. Not to mention, with increased gender equity, we can expect to reduce gender bias in scientific results. Perhaps Muriel Lederman, winner of the 2003 Advancing Women Award at Virginia Tech said it best:

“Science is hegemonic and androcentric, two characteristics that proceed from the fact that practitioners of science as we know it have traditionally been white, male, and Western. It is they who define the rules, methods, instrumentation, descriptions of results, and criteria for knowledge production. It is they who define what counts as science, both theoretically and in practice. It is they who are the gatekeepers for access to, and definers of, a life in science (Lederman 2003).”
The further involvement of women in science and particularly in physics is beneficial to the advancement of technology and to pushing the frontiers of knowledge. According to medical doctor, architect and TED Fellow Rachel Armstrong of the University of Greenwich, women display many qualities that are needed in science and technology fields. "Women tend to facilitate, cooperate, nurture and orchestrate," says Armstrong: "Their approach is less 'top-down, fix the broken machine' than it is holistic and collaborative, a great asset in science and engineering." Melissa Sterry, Head of Technology at Earth 2 Hub, agrees, pointing out that the social roles women play could be invaluable in our search as a people for sustainable technologies. “As family members and mothers,” says Terry, “women understand sustainability as a way of securing the future.” (Rowland 2013)

Of all of the sciences, physics continues to have the lowest representation of women. The issue of gender disparity in physics is one that has been of great concern and has therefore been studied rigorously for many years. An important step in the ultimate goal of remedying this problem is understanding why it exists in the first place. Identified culprits range from the types of toys children play with (Measor and Sikes 1992) to the average temperature of high school classrooms (Sax 2006). This study is an attempt to build on the current collection of identified factors contributing to the gender gap in physics.
Contributing Factors

According to a report published by the American Institute of Physics, forty-six percent of high school students taking physics are girls. Twenty-two percent of physics bachelor’s degree recipients and eighteen percent of physics PhD recipients are female. Only ten percent of physics faculty and five percent of full professors of physics are women. In fact, over twenty percent of PhD granting physics departments have no female faculty at all. (Ivie and Ray 2005)

Though these statistics are alarming, we should be careful to recognize that the increase in female physics bachelor degree recipients over the last fifty years or so actually matches what would be expected for women advancing at the same rate as men. For example, the current proportion of female physics faculty members matches the proportion of female physics PhD recipients during the period when the majority of those faculty members were earning their degrees. Therefore, the metaphorical leak in the pipeline must exist at some point before women receive bachelor’s degrees. (Ivie and Ray 2005)

It has often been posited that males and females excel in different fields due to societal expectations, parental influence, peer-pressure and teacher expectations. For most of the population, this pattern begins at an early age. Mothers tend to nurture and talk to female toddlers more and keep them close by, whereas boys are encouraged to explore and are allowed to wander farther (Dembo 1994). When a little girl falls off her bike she is cuddled and receives sympathy, whereas in the same situation, a boy is pushed on and told to try again (Dowling 1981). Girls are encouraged to be passive where boys
are allowed to be aggressive (Jewett 1996). This continues on through middle school and high school, where if a girl has difficulty solving a problem she is often told the answer where a boy is told to keep trying (Rothman 1991). Boys are also eight times more likely to call out in class and five times more likely to receive attention from teachers (Bailey 1995).

Furthermore, girls’ toys emphasize society and community while boys’ employ competition and problem solving. Boys are more likely to play with toys that mimic construction, battle, or adventure whereas girls commonly choose toys that implement housekeeping and care-taking and imitate family life. In boys, this difference in toy choice leads to the development of greater spatial and mechanical skills, which are necessary for formal learning in science (Measor and Sikes 1992).

Once students get into middle school and are required to work in a laboratory setting, the boys tend to do the hands on work while the girls tend to write down the observations (Lee 1980). By third grade, thirty-seven percent of females have used microscopes while fifty-one percent of males have, and by eleventh grade, only seventeen percent of girls have used a multi-meter while forty-nine percent of boys have (Hanson 1992). This lack of experience obviously leaves girls at a disadvantage once they enter college.

A study performed by the University of Colorado showed that the key determining factor for success in introductory physics is prior knowledge and preparation. Students of both genders with similar pretest scores show comparable gains on posttest scores, meaning that both genders apparently gain the same amount of
knowledge from the course. The study also showed a strong correlation between math proficiency and physics achievement. This indicates that at least part of the reason for the gender gap can be attributed to girls’ tendency to avoid math in earlier schooling. (Kost, Pollock and Finkelstein 2009)

A lack of adequate female role models in science also contributes to the gender gap and is of particular concern because it is self-perpetuating. It has been shown that females are more likely to enter a field when they are able to identify a role model in that field (Lent 1994). Scientists are consistently portrayed in the media, and therefore stereotyped by students, as nerdy, white, and male (Eisenhart, Finkel and Marion 1996). This image clashes with girls’ preferred images of themselves. Both genders consider math and science as “male” as early as the second grade, making such observations as “girls avoid science because they don’t want a brainy image” and “girls can’t get into science because it just doesn’t have anything to do with their future or careers (Hanson 1992).”

Also, females tend to have negative reactions to the idea of achieving more than their same-sex friends, saying that they would be unhappy and that their friends would be angry with them. Males, in general, do not experience such negative reactions. Perhaps this is another reason that girls don’t tend to excel in math or science. They could be worried that they will be rejected by their friends. Furthermore, females tend to strive for equality while men are comfortable with hierarchy in both personal and professional relationships. Women may therefore feel threatened by the competitive and hierarchical nature of STEM fields. (Benenson and Schinazi 2004)
Societal and cultural expectations play a huge part in our decision making and have a large influence on our personal expectations and even on our performance. In a prominent study done in Vancouver on stereotype threat, women took a math test after completing a reading comprehension section. Some of the women were given a fake essay about how men have genes that make them better at math, while the other women were given an essay about how differences in math ability are experiential and can be overcome. The first group of women did a full fifty percent worse on the math test than the second group. The existence of a widespread societal belief that women are not as capable as men in physics would lead to this sort of stereotype threat, thereby perpetuating the gender gap. (Dar-Nimrod and Heine 2006)

Traditionally it was assumed that these societal and cultural attitudes were the sole reason for the gender gap in science. However, in the past few decades scientists have discovered several physiological and neurological differences in boys and girls that effect how they learn. For instance, in some circumstances, a woman’s sense of smell can be one hundred thousand times more sensitive than a man’s, to the point where a room that is perfectly ordinary to a man could be filled with a smell that a woman may find actually nauseating (Dalton, Doolittle and Breslin 2002). Girls are also born with far more sensitive hearing than boys, particularly at the frequencies where small deviations in speech that indicate mood and feeling can be recognized (Jewett 1996). Studies have even shown that girls need an ambient room temperature of about six degrees higher than boys for an ideal learning environment (Sax 2006).
Important differences between genders can also be observed in the autonomic nervous system, the system that responds to violence or confrontation. Females’ autonomic nervous systems have been shown to be influenced more by the parasympathetic nervous system, which when activated produces feelings of dizziness, mental slowing and imagined paralysis. These feelings are often stressful, unpleasant and even nauseating. The autonomic nervous systems of males, on the other hand, tend to be influenced more by their sympathetic nervous system, which leads to sharpened senses, arousal, and excitement, and is usually experienced as thrilling or arousing (Evans, et al. 2001). These differences indicate that girls naturally learn better in different environments than boys.

There is, in fact, plentiful evidence for the link between stress response and learning in members of both sexes. A series of studies done at Rutgers University showed that experiencing stress makes females become extremely handicapped in their ability to learn, but males are the opposite. Males actually demonstrate enhanced performance after experiencing the same kind of stress (Shors 2002). Also, men show significantly greater cortisol responses to stress related to achievement, but women show greater cortisol responses to stress related to social rejection (Stroud, Salovey and Epel 2002). Since the release of cortisol increases energy and heightens memory functions, this would greatly impact how people of different sexes learn.

According to a study done by Andrzej Urbanik, chair of Radiology at Jagiellonian University Hospital in Krakow, males pay more attention to the sensory aspects of emotional stimuli and deal with them in terms of how they’re required to respond, but
women focus on the feelings brought about by the emotional stimuli (Radiology Society of North America 2009). Along the same lines, a study done at University of California, Los Angeles, showed that while males react to stress with aggression or withdrawal, females react by seeking out social support. “When faced with stressful situations, men attempt to analyze the circumstances and devise solutions -- sometimes involving either fight or flight. Women, on the other hand, look for others to assist them with the problem in order to remove the cause of stress (Taylor, et al. 2000).” This implies that a teaching practice that involves group work may have a positive impact on female students.

**Previously Identified Correlations**

Many correlations were discovered throughout the course of this study. The following sections will review the literature on those correlations, including parents’ education level and achievement, number of siblings and achievement, algebra ability and achievement in physics, and number of siblings and gender.

**Parents’ Education Level and Achievement**

One factor that has been consistently identified in the achievement of students is the amount of education their parents have attained. One study showed that students’ test scores correlated significantly with mothers’ years of schooling (Chiu and Khoo 2005), while multiple studies have shown that a large part of the variance in educational attainment in men can attributed to parental schooling (Kuo and Hauser 1995; Duncan 1967). A study done at the National Center for Education Statistics showed that 88% of parents who had earned at least a bachelor’s degree expected their children to finish
college, while only 44% of parents who had graduated from high school or less expected their children to finish college (Lippman, et al. 2008). As Julie K. Nelson, a speaker and professor at Utah Valley University, points out “Whether the parent’s GPA is tied to intelligence or disciplined study or both, these traits and behaviors are passed down to their children.” She goes on to state that

“College-educated parents are typically more aware of the long-term benefits of acquiring a college degree, and thus they share this information with their children. The higher the degree the parents have obtained, the greater the support the student will have from their parents to complete a similar academic goal. Parents who have not attended college, on the other hand, tend to have less direct knowledge of the economic and social benefits of a postsecondary education. Thus, some of these parents may prefer that their children work rather than attend college.” (Nelson 2009)

Number of Siblings and Achievement

Another factor that has consistently been found to impact student achievement is the number of siblings the student has. Individuals with the fewest siblings have been found to be the most successful across numerous measures of educational attainment, intellectual achievement, and cognitive skills (Hauser and Kuo 1998; Duncan 1967; Cicirelli 1978). According to Douglas Downey of Ohio State University, the main reason for this trend is resource dilution. “The resource dilution model posits that parental resources are finite and that as the number of children in the family increases, the resources accrued by any one child necessarily decline. Siblings are competitors for parents' time, energy, and financial resources and so the fewer the better (Downey 2001).”
Algebra Ability and Motivation in Physics

In physics, a positive relationship has been well established between attitude or interest in physics and achievement (von Rhoneck, et al. 1998; Lawrenz, et al. 2009). Not surprisingly, motivation to understand physics has been shown to be another predictor of physics achievement (Norvilitis, Reid and Norvilitis 2002). Mathematics background and achievement has also been shown to predict physics achievement (Lawrenz, et al. 2009; Norvilitis, Reid and Norvilitis 2002).

Number of Siblings and Gender

It has been well established that males with more male siblings display more feminine characteristics and are more likely to be homosexual or transgender (Blanchard 1997; Schagen, et al. 2012). There is evidence that the reason for this is biological in nature, and likely a result of a maternal immune response (Bogaert 2006). Much less research has been done on female gender and sexuality, and those studies that have been done have been mostly inconclusive (Zucker, et al. 1998; Blanchard 1997; Bogaert 1997). However, some studies have shown that gender dysphoric girls tend to have fewer siblings, and are particularly likely to be only children. (Schagen, et al. 2012; Katz and Rank 1981). The mechanism responsible for this remains unknown (Schagen, et al. 2012).

Purpose of the Study
This study is an attempt to identify contributing factors to the gender gap in physics, but what if the reasons for the “gender gap” were actually related to “gender,” and not just “sex”? Although often used interchangeably, in the educational research context, these two words actually have distinct meanings. A person’s “sex” is determined by whether they are physiologically a male or a female. A person’s “gender”, on the other hand, is much more complicated and incorporates not only their sexual preference, but their lifestyle, femininity and masculinity, and the sex that they prefer to present themselves as. As the Oxford English Dictionary states, “The word sex tends now to refer to biological differences, while gender often refers to cultural or social ones.” This study will examine correlations of not only sex and physics achievement, but also of gender and physics achievement.
CHAPTER 2

METHODOLOGY

Tests and Surveys

The following are descriptions of the various tests and surveys administered to the subjects of this study. Subjects were given a pretest at the beginning of the semester, which included Paul Hewitt’s Sixty Questions Physics Students Should Know and the Mechanics Baseline Test as well as an algebra test and a habits survey. At the end of the semester they were given a posttest, which was identical to the pretest, as well as a social survey, the Maryland Physics Expectations Survey, and the Bem Gender Role Survey. Full versions of all administered tests and surveys are supplied in the appendix.

Sixty Questions Physics Students Should Know

Paul Hewitt developed this multiple choice test to determine whether or not students were grasping the basic concepts in introductory physics classes. As he states on his website, these questions have been “honed by use and reuse over my teaching career at City College of San Francisco.” He goes on to say, “I see the questions as straightforward, without tricks or subtleties, treating only essential content, which every student should be able to answer after completing an introductory physics course (Hewitt n.d.).” Hewitt’s permission was obtained for the use of his test because of his reputation
for high quality and because of a desire to evaluate students’ actual understanding of the basic concepts in physics, not just their ability to memorize equations. As the test was written for both semesters of introductory physics, and our study only took place over the first semester, twenty-six of Hewitt’s sixty questions were selected for use on our surveys.

**Mechanics Baseline Test**

The Mechanics Baseline Test was designed by David Hestenes and Malcolm Wells at Arizona State University “to assess student understanding of the most basic concepts in mechanics. The test is universal in the sense that it is limited to concepts that should be addressed in introductory physics at any level from high school through Harvard University (Hestenes and Wells 1992).” The questions are designed to evaluate concepts and principles that students would not be able to answer without formal knowledge of physics. This made the test an appropriate tool for use in our study, since we desired to evaluate the knowledge gained from a formal physics course. We selected nine questions from the test that we decided were appropriate for the course that the study was evaluating.

**Algebra Assessment**

This algebra assessment was chosen for use in this study as a means to evaluate any possible correlations between algebra skill and achievement. The algebra assessment was created by Andrew Gnefkow, a graduate student in the physics department at University of Missouri - Kansas City, for use in a previous study. The assessment was
designed to evaluate students’ basic algebra abilities. The test was made up of nine questions which examined three areas of skill: algebraic equations, quadratic equations, and systems of equations. (Gnefkow 2011)

**Bem Sex-Role Inventory**

The Bem Sex Role Inventory was chosen for use in this study as a means to evaluate the gender identities of the subjects involved. Sandra Bem constructed the BSRI in 1974 because she felt that the gender tests available at the time were not adequate. Bem and her students came up with a list of 400 personality traits, half of which they felt were gender neutral and half of which they felt were culturally attributed to one gender or the other. They then gave the list to two groups of students from Stanford University. One of the groups rated the traits as desirable for males and the other group rated them as desirable for females. Each group had half male and half female participants. Only traits that had a significant difference between their male and female scores were chosen to represent each gender, and both males and females had to agree. Out of these, the strongest ten desirable traits and the strongest ten undesirable traits were chosen. The final list is reproduced in Appendix A. (Davis 2009)

The test is taken by ranking how well each trait describes the subject. Then the subject is given a masculine and a feminine score, not just one score on a continual scale. The reason for this is that Bem felt that masculinity and femininity are logically separate, a claim which has been supported through the years. The BSRI continues to be the most widely used gender test in the social sciences. (Davis 2009)
For the current study, it was decided that the results of the BRSI should be manipulated into a new variable. This was done to account for the fact that the BSRI was constructed for individual use and not for large scale studies. The details of this new variable are discussed in chapter 3.

Maryland Physics Expectations Survey

According to its creators, the Maryland Physics Expectations Survey was “developed by the Maryland Physics Education Research Group as part of a project to study the attitudes, beliefs, and expectations of students that have an effect on what they learn in an introductory calculus-based physics course. Students are asked to agree or disagree on a five point scale with 34 statements about how they see physics and how they think they work in their physics course (Redish 2001).”

This survey was chosen as a means to look at how different attitudes and expectations are correlated with gender and achievement in physics.

Habits and Social Surveys

The habits survey was created for use in this study for the purpose of evaluating any possible correlations between students’ diligence, preference for working in groups and achievement in physics. The social survey was created to establish possible correlations between achievement in physics and the sex make-up of students’ social networks, the number of siblings students had, and their parents’ education levels.
CHAPTER 3
RESULTS AND DISCUSSION

Data was analyzed using IBM SPSS Statistics, a computer software program used for statistical analysis. The original SPSS manual has been described as "Sociology's Most Influential Recent Book" (Wellman 1998). A current version of that manual can be found on IBM’s website at ftp://public.dhe.ibm.com/software/analytics/spss/documentation/statistics/20.0/en/client/Manuals/IBM_SPSS_Statistics_Core_System_Users_Guide.pdf.

Reliability Analyses

The tables in the following sections show the results of the Cronbach’s Alpha Reliability Test performed for each test used in this study. Cronbach’s alpha is expressed as a number between zero and one, and it provides a measure of the internal consistency of a test. Internal consistency is the extent to which all of the questions on a test measure the same concept. A test with a Cronbach’s Alpha of .7 or greater is widely considered as acceptably reliable. Also, ideally, all of the items on each test will have a positive Item-Total Correlation, meaning that a correct answer to each item on the test is positively correlated with a correct answer to each other item. (Tavakol and Dennick 2011)
Posttest

Questions # 3, 4, 6, and 8 on the Mechanics Baseline Test were removed because they were found to be unreliable by the Chronbach’s Alpha Reliability Test. An individual item analysis shows that all of the items on the posttest were positively correlated. The results can be found in Table 1.

<table>
<thead>
<tr>
<th>Item</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
<th>Item</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>HewittFinal1</td>
<td>0.32</td>
<td>0.707</td>
<td>HewittFinal17</td>
<td>0.189</td>
<td>0.716</td>
</tr>
<tr>
<td>HewittFinal2</td>
<td>0.127</td>
<td>0.721</td>
<td>HewittFinal18</td>
<td>0.274</td>
<td>0.711</td>
</tr>
<tr>
<td>HewittFinal3</td>
<td>0.36</td>
<td>0.71</td>
<td>HewittFinal19</td>
<td>0.38</td>
<td>0.703</td>
</tr>
<tr>
<td>HewittFinal4</td>
<td>0.249</td>
<td>0.713</td>
<td>HewittFinal20</td>
<td>0.305</td>
<td>0.709</td>
</tr>
<tr>
<td>HewittFinal5</td>
<td>0.344</td>
<td>0.709</td>
<td>HewittFinal21</td>
<td>0.121</td>
<td>0.721</td>
</tr>
<tr>
<td>HewittFinal6</td>
<td>0.077</td>
<td>0.724</td>
<td>HewittFinal22</td>
<td>0.135</td>
<td>0.72</td>
</tr>
<tr>
<td>HewittFinal7</td>
<td>0.154</td>
<td>0.718</td>
<td>HewittFinal23</td>
<td>0.116</td>
<td>0.72</td>
</tr>
<tr>
<td>HewittFinal8</td>
<td>0.361</td>
<td>0.705</td>
<td>HewittFinal24</td>
<td>0.225</td>
<td>0.714</td>
</tr>
<tr>
<td>HewittFinal9</td>
<td>0.254</td>
<td>0.712</td>
<td>HewittFinal25</td>
<td>0.313</td>
<td>0.708</td>
</tr>
<tr>
<td>HewittFinal10</td>
<td>0.488</td>
<td>0.696</td>
<td>HewittFinal26</td>
<td>0.171</td>
<td>0.718</td>
</tr>
<tr>
<td>HewittFinal11</td>
<td>0.308</td>
<td>0.709</td>
<td>MBLTFinal1</td>
<td>0.395</td>
<td>0.704</td>
</tr>
<tr>
<td>HewittFinal12</td>
<td>0.282</td>
<td>0.71</td>
<td>MBLTFinal2</td>
<td>0.075</td>
<td>0.724</td>
</tr>
<tr>
<td>HewittFinal13</td>
<td>0.154</td>
<td>0.718</td>
<td>MBLTFinal5</td>
<td>0.208</td>
<td>0.715</td>
</tr>
<tr>
<td>HewittFinal14</td>
<td>0.32</td>
<td>0.707</td>
<td>MBLTFinal7</td>
<td>0.129</td>
<td>0.72</td>
</tr>
<tr>
<td>HewittFinal15</td>
<td>0.243</td>
<td>0.713</td>
<td>MBLTFinal9</td>
<td>0.244</td>
<td>0.713</td>
</tr>
<tr>
<td>HewittFinal16</td>
<td>0.022</td>
<td>0.726</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results of the Chronbach’s Alpha Reliability Test performed on the posttest showed that it had an acceptable level of reliability. The results can be found in Table 2.

Reliability Statistics for Posttest

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.720</td>
<td>31</td>
</tr>
</tbody>
</table>

Algebra Assessment

An individual item analysis shows that all of the items on the posttest were positively correlated. These results can be found in Table 3. Item Total Statistics for Algebra Assessment

<table>
<thead>
<tr>
<th>Algebra1</th>
<th>Corrected Item-Total Correlation</th>
<th>.294</th>
<th>.695</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algebra2</td>
<td>.407</td>
<td></td>
<td>.677</td>
</tr>
<tr>
<td>Algebra3</td>
<td>.287</td>
<td></td>
<td>.696</td>
</tr>
<tr>
<td>Algebra4</td>
<td>.469</td>
<td></td>
<td>.666</td>
</tr>
<tr>
<td>Algebra5</td>
<td>.364</td>
<td></td>
<td>.684</td>
</tr>
<tr>
<td>Algebra6</td>
<td>.370</td>
<td></td>
<td>.682</td>
</tr>
<tr>
<td>Algebra7</td>
<td>.403</td>
<td></td>
<td>.675</td>
</tr>
<tr>
<td>Algebra8</td>
<td>.405</td>
<td></td>
<td>.675</td>
</tr>
<tr>
<td>Algebra9</td>
<td>.433</td>
<td></td>
<td>.669</td>
</tr>
</tbody>
</table>
The results of the Chronbach’s Alpha Reliability Test performed on the algebra assessment showed that the posttest had an acceptable level of reliability. These results can be found in Table 4. Reliability Statistics for Algebra Assessment

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.705</td>
<td>9</td>
</tr>
</tbody>
</table>

Bem Gender Role Survey

The results of the Chronbach’s Alpha Reliability Test performed on the Feminine portion of the Bem Gender Role Survey showed that the posttest had an acceptable level of reliability. These results can be found in Table 5.

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.762</td>
<td>20</td>
</tr>
</tbody>
</table>
An individual item analysis shows that all of the items on the feminine portion of the Bem Gender Role Survey were positively correlated. The results can be found in Table 6. Item-Total Statistics for Bem Gender Role Survey: Feminine

Table 6. Item-Total Statistics for Bem Gender Role Survey: Feminine

<table>
<thead>
<tr>
<th>Item</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSRIF1</td>
<td>.109</td>
<td>.767</td>
</tr>
<tr>
<td>BSRIF2</td>
<td>.398</td>
<td>.749</td>
</tr>
<tr>
<td>BSRIF3</td>
<td>.015</td>
<td>.776</td>
</tr>
<tr>
<td>BSRIF4</td>
<td>.557</td>
<td>.741</td>
</tr>
<tr>
<td>BSRIF5</td>
<td>.108</td>
<td>.767</td>
</tr>
<tr>
<td>BSRIF6</td>
<td>.354</td>
<td>.751</td>
</tr>
<tr>
<td>BSRIF7</td>
<td>.478</td>
<td>.739</td>
</tr>
<tr>
<td>BSRIF8</td>
<td>.525</td>
<td>.740</td>
</tr>
<tr>
<td>BSRIF9</td>
<td>.506</td>
<td>.742</td>
</tr>
<tr>
<td>BSRIF10</td>
<td>.638</td>
<td>.734</td>
</tr>
<tr>
<td>BSRIF11</td>
<td>.391</td>
<td>.749</td>
</tr>
<tr>
<td>BSRIF12</td>
<td>.642</td>
<td>.732</td>
</tr>
<tr>
<td>BSRIF13</td>
<td>.065</td>
<td>.774</td>
</tr>
<tr>
<td>BSRIF14</td>
<td>.435</td>
<td>.745</td>
</tr>
<tr>
<td>BSRIF15</td>
<td>.626</td>
<td>.731</td>
</tr>
<tr>
<td>BSRIF16</td>
<td>.130</td>
<td>.770</td>
</tr>
<tr>
<td>BSRIF17</td>
<td>.065</td>
<td>.772</td>
</tr>
<tr>
<td>BSRIF18</td>
<td>.147</td>
<td>.771</td>
</tr>
<tr>
<td>BSRIF19</td>
<td>.342</td>
<td>.751</td>
</tr>
<tr>
<td>BSRIF20</td>
<td>.535</td>
<td>.737</td>
</tr>
</tbody>
</table>
An individual item analysis shows that all of the items on the masculine portion of the Bem Gender Role Survey were positively correlated. The results can be found in Table 7.

Table 7. Item-Total Statistics for Bem Gender Role Survey: Masculine

<table>
<thead>
<tr>
<th>Item</th>
<th>Corrected Item-Total Correlation</th>
<th>Cronbach's Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSRIM1</td>
<td>.499</td>
<td>.837</td>
</tr>
<tr>
<td>BSRIM2</td>
<td>.451</td>
<td>.840</td>
</tr>
<tr>
<td>BSRIM3</td>
<td>.332</td>
<td>.844</td>
</tr>
<tr>
<td>BSRIM4</td>
<td>.331</td>
<td>.844</td>
</tr>
<tr>
<td>BSRIM5</td>
<td>.597</td>
<td>.832</td>
</tr>
<tr>
<td>BSRIM6</td>
<td>.668</td>
<td>.829</td>
</tr>
<tr>
<td>BSRIM7</td>
<td>.481</td>
<td>.838</td>
</tr>
<tr>
<td>BSRIM8</td>
<td>.203</td>
<td>.848</td>
</tr>
<tr>
<td>BSRIM9</td>
<td>.271</td>
<td>.845</td>
</tr>
<tr>
<td>BSRIM10</td>
<td>.645</td>
<td>.830</td>
</tr>
<tr>
<td>BSRIM11</td>
<td>.446</td>
<td>.839</td>
</tr>
<tr>
<td>BSRIM12</td>
<td>.425</td>
<td>.840</td>
</tr>
<tr>
<td>BSRIM13</td>
<td>.595</td>
<td>.832</td>
</tr>
<tr>
<td>BSRIM14</td>
<td>.184</td>
<td>.857</td>
</tr>
<tr>
<td>BSRIM15</td>
<td>.639</td>
<td>.831</td>
</tr>
<tr>
<td>BSRIM16</td>
<td>.308</td>
<td>.846</td>
</tr>
<tr>
<td>BSRIM17</td>
<td>.503</td>
<td>.836</td>
</tr>
<tr>
<td>BSRIM18</td>
<td>.187</td>
<td>.848</td>
</tr>
<tr>
<td>BSRIM19</td>
<td>.435</td>
<td>.840</td>
</tr>
<tr>
<td>BSRIM20</td>
<td>.498</td>
<td>.837</td>
</tr>
</tbody>
</table>
The results of the Chronbach’s Alpha Reliability Test performed on the Masculine portion of the Bem Gender Role Survey showed that the posttest had an acceptable level of reliability. The results can be found in Table 8.

<table>
<thead>
<tr>
<th>Table 8. Reliability Statistics for Bem Gender Role Survey: Masculine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cronbach's Alpha</strong></td>
</tr>
<tr>
<td>.847</td>
</tr>
</tbody>
</table>

**Formation of Social, Attitudes, and Habits Variables**

To form the various factors that described the subjects’ habits, attitudes, and social groups, principal component analysis and varimax rotation were performed on a collection of questions from the surveys used in this study. Through this analysis, we can take a large number of correlated variables and combine them into a small number of factors.

In a principal component analysis, a small number of latent, or hidden, factors are extracted from a large set of specific variables. This is done by measuring which variables are correlated with one another and combining those that are into factors. For instance, the three variables “arm length”, “leg length”, and “height” could all be combined into one factor called “body length”. Factors that are extracted from the same set of variables are assumed to be orthogonal, or uncorrelated, with each other. Once factors are extracted, each specific variable is plotted on a factor matrix. A factor matrix is similar to a Cartesian coordinate system, but each of the axes represents a factor, and
each data point represents a variable, in the case of this study, a question on a survey. This matrix shows each variable’s relationship to each of the factors. Each variable is then characterized by factor loadings, or correlation coefficients, between the variable and each of the factors. These factor loadings range from -1 to 1, with 0 being the mean. The squared factor loading is the percentage of variance in the variable. (Pett, Lackey and Sullivan 2003)

Once the factor matrix has been constructed, a varimax rotation is performed to maximize the variances of the squared factor loadings for all of the variables for each factor. This basically means that the axes of the factor matrix are rotated in such a way that each variable lands as close as possible to one of the factor axes. (Pett, Lackey and Sullivan 2003)

Social Factors

A varimax rotation was performed on selected questions from the Social Survey. The percent variance accounted for by each of the factors extracted is shown in Table 9. Three factors were extracted and arranged in a rotated component matrix which can be found in Table 10. Each factor corresponds to a set of statements from the social survey. The first factor extracted corresponds to a preference for male friends, the second, a closer relationship with a male parent or guardian, and the third, a preference for male teachers.
Table 9. Total Variance Explained for Social Factors

<table>
<thead>
<tr>
<th>Component</th>
<th>Rotation Sums of Squared Loadings</th>
<th>% of Variance</th>
<th>Cumulative %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Preference for Male Friends</td>
<td>26.676</td>
<td>26.676</td>
<td></td>
</tr>
<tr>
<td>2: Closer to Male Parent</td>
<td>18.798</td>
<td>45.474</td>
<td></td>
</tr>
<tr>
<td>3: Preference for Male Teachers</td>
<td>17.539</td>
<td>63.013</td>
<td></td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.

Table 10. Rotated Component Matrix for Social Factors

<table>
<thead>
<tr>
<th>Component</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>My closest friends are mostly male</td>
<td>1.801</td>
</tr>
<tr>
<td>When I participate in a social event, the people I go with are usually</td>
<td>-0.046</td>
</tr>
<tr>
<td>mostly male.</td>
<td>0.239</td>
</tr>
<tr>
<td>My current best friend is male.</td>
<td>0.661</td>
</tr>
<tr>
<td>When I participate in a social event, the people I go with are mostly</td>
<td>-0.159</td>
</tr>
<tr>
<td>mostly male.</td>
<td>0.104</td>
</tr>
<tr>
<td>My current best friend is male.</td>
<td>0.661</td>
</tr>
<tr>
<td>When I am required to participate in a group activity for school, I</td>
<td>-0.046</td>
</tr>
<tr>
<td>usually choose group members who are mostly male</td>
<td>0.239</td>
</tr>
<tr>
<td>When I have a problem and wish to seek parental advice, I usually go</td>
<td>0.045</td>
</tr>
<tr>
<td>to my male guardian</td>
<td>0.851</td>
</tr>
<tr>
<td>My male guardian has been more active than my female guardian</td>
<td>-0.188</td>
</tr>
<tr>
<td>Overall, I feel that I relate best to male teachers.</td>
<td>0.029</td>
</tr>
<tr>
<td>My favorite teacher or professor is male.</td>
<td>-0.028</td>
</tr>
<tr>
<td>Extraction Method: Principal Component Analysis.</td>
<td>0.820</td>
</tr>
<tr>
<td>Rotation Method: Varimax with Kaiser Normalization.</td>
<td>0.748</td>
</tr>
<tr>
<td>a. Rotation converged in 5 iterations.</td>
<td></td>
</tr>
</tbody>
</table>
Attitudes and Habits Factors

A varimax rotation was performed on selected questions from the Habits Survey and the Maryland Physics Expectations Survey. The percent variance accounted for by each of the factors extracted is shown in Table 11. Three factors were extracted and arranged in a rotated component matrix which can be found in Table 12. Each factor corresponds to a set of statements from the surveys. Statements associated with a negative attitude are indicated by a (-) in front of the statement. The first factor extracted corresponds to a preference for group work, the second, a preference for learning physics conceptually, and the third, a desire for a thorough understanding of physics.

Table 11. Total Variance Explained for Attitudes and Habits Variables

<table>
<thead>
<tr>
<th>Component</th>
<th>Rotation Sums of Squared Loadings</th>
<th>Percent of Variance</th>
<th>Cumulative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Conceptual Learners</td>
<td></td>
<td>12.477</td>
<td>26.581</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Table 12. Rotated Component Matrix for Attitudes and Habits Variables

<table>
<thead>
<tr>
<th></th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughout the semester, I use study groups to gain a better understanding of the material being taught in class.</td>
<td>0.866</td>
<td>-0.143</td>
<td>-0.081</td>
</tr>
<tr>
<td>When completing my homework, I work in a small group.</td>
<td>0.829</td>
<td>-0.050</td>
<td>-0.090</td>
</tr>
<tr>
<td>Throughout the semester, I use study groups to prepare for exams.</td>
<td>0.813</td>
<td>-0.018</td>
<td>-0.042</td>
</tr>
<tr>
<td>Throughout the semester, I use study groups to complete my lab reports.</td>
<td>0.791</td>
<td>0.071</td>
<td>0.019</td>
</tr>
<tr>
<td>When I’m studying physics in a study group I feel that I’m learning a lot.</td>
<td>0.555</td>
<td>0.000</td>
<td>0.228</td>
</tr>
<tr>
<td>When completing an assignment, I would rather work in a group.</td>
<td>0.512</td>
<td>-0.180</td>
<td>0.143</td>
</tr>
<tr>
<td>(-) If I don’t remember a particular equation needed for a problem in an exam there’s nothing much I can do (legally!) to come up with it.</td>
<td>0.078</td>
<td>0.760</td>
<td>0.018</td>
</tr>
<tr>
<td>(-) The derivations or proofs of equations in class or in the text have little to do with solving problems or with the skills I need to succeed in this course.</td>
<td>-0.004</td>
<td>0.665</td>
<td>-0.044</td>
</tr>
<tr>
<td>(-) The best way for me to learn physics is by solving many problems rather than by carefully analyzing a few in detail.</td>
<td>0.084</td>
<td>0.662</td>
<td>0.011</td>
</tr>
<tr>
<td>(-) ‘Problem solving’ in physics basically means matching problems with facts or equations and then substituting values to get a number.</td>
<td>-0.170</td>
<td>0.564</td>
<td>-0.043</td>
</tr>
<tr>
<td>(-) Physical laws have little relation to what I experience in the real world.</td>
<td>-0.269</td>
<td>0.490</td>
<td>0.063</td>
</tr>
<tr>
<td>(-) In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens.</td>
<td>-0.214</td>
<td>0.476</td>
<td>0.234</td>
</tr>
<tr>
<td>(-) In doing a physics problem, if my calculation gives a result that differs significantly from what I expect, I’d have to trust the calculation.</td>
<td>-0.420</td>
<td>0.465</td>
<td>-0.180</td>
</tr>
<tr>
<td>(-) All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.</td>
<td>-0.152</td>
<td>0.453</td>
<td>0.003</td>
</tr>
<tr>
<td>(-) Only very few specially qualified people are capable of really understanding physics.</td>
<td>0.030</td>
<td>0.453</td>
<td>-0.012</td>
</tr>
<tr>
<td>(-) The main skill I get out of this course is learning how to solve physics problems.</td>
<td>-0.013</td>
<td>0.413</td>
<td>-0.224</td>
</tr>
<tr>
<td>(-) The most crucial thing in solving a physics problem is finding the right equation to use.</td>
<td>0.041</td>
<td>0.346</td>
<td>0.055</td>
</tr>
<tr>
<td>I need to have an understanding of physics to achieve my career goals.</td>
<td>0.154</td>
<td>-0.032</td>
<td>0.704</td>
</tr>
<tr>
<td>I read the text in detail and work through many of the examples given there.</td>
<td>0.055</td>
<td>-0.048</td>
<td>0.658</td>
</tr>
<tr>
<td>A good understanding of physics is necessary for me to achieve my career goals. A good grade in this course is not enough.</td>
<td>0.058</td>
<td>-0.105</td>
<td>0.606</td>
</tr>
<tr>
<td>Learning physics made me change some of my ideas about how the physical world works.</td>
<td>0.159</td>
<td>0.227</td>
<td>0.596</td>
</tr>
<tr>
<td>I spend a lot of time figuring out and understanding at least some of the derivations or proofs given either in class or in the text.</td>
<td>0.093</td>
<td>0.083</td>
<td>0.557</td>
</tr>
<tr>
<td>I read sections of the text book when I find that I do not understand a particular concept.</td>
<td>-0.194</td>
<td>0.045</td>
<td>0.524</td>
</tr>
<tr>
<td>When I’m in physics lecture I feel that I’m learning a lot.</td>
<td>-0.078</td>
<td>0.080</td>
<td>0.464</td>
</tr>
<tr>
<td>Throughout the semester, I complete my homework at least a day before it is due.</td>
<td>-0.057</td>
<td>-0.207</td>
<td>0.396</td>
</tr>
<tr>
<td>I go over my class notes carefully to prepare for tests in this course.</td>
<td>0.119</td>
<td>0.020</td>
<td>0.338</td>
</tr>
<tr>
<td>I attend class on a regular basis.</td>
<td>-0.164</td>
<td>-0.153</td>
<td>0.274</td>
</tr>
</tbody>
</table>

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.
Descriptive Statistics

This study was administered to 209 subjects, 82 of which sufficiently completed the study to be included in the analysis. Of those 82 subjects, 55 were female and 27 were male.

On the pretest, females scored 6.2% lower, on average, than males. On the posttest, they scored 7.1% lower. This information is demonstrated in Error! Reference source not found.. This shows that the course being studied may have contributed slightly to the gender gap in physics, but mostly it maintained the gap already in place.

The average score on the math test was 73.33% for females and 75.72% for males.

Figure 1. Average Pretest and Posttest with Error Bars

<table>
<thead>
<tr>
<th></th>
<th>Female Average</th>
<th>Male Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>28.33</td>
<td>34.53</td>
</tr>
<tr>
<td>Posttest</td>
<td>35.31</td>
<td>42.41</td>
</tr>
</tbody>
</table>
The BSRI showed some unconventional results. As shown in Error! Reference source not found., both males and females rated themselves as more masculine than feminine, and females rated themselves as higher on both the feminine and the masculine scale.

There are many possible reasons for these unconventional results. The highest predictor of masculine score was feminine score. This indicates that some students were just more heavy handed with rating themselves than others across the board. Also, we must remember that the subjects involved in this study were not a representation of the populace as a whole, but were all students enrolled in a physics class. This could be evidence of a leak in the metaphorical pipeline. It is possible that the more feminine portion of the student population may be missing from this sample because they have

![Figure 1. Feminine and Masculine BSRI Scores for Males and Females](image)
self-selected themselves out of physics by this point. Therefore, the subjects might have more masculine characteristics than the general public.

Because of these results, it was decided that a new factor should be created that could resolve the issues mentioned above. This was done by dividing a subject’s masculine score by their masculine score plus their feminine score. On this new factor, a score of 0 would represent absolute femininity, a score of 50 would represent someone who scored equally on the feminine and masculine scales, and someone with a score of 100 would be completely masculine. As shown on Error! Reference source not found. and Table 13, the new factor had more conventional results. However, notice that the females still had an average score of more than 50 and that the range is heavily shifted toward the masculine side of the scale. This is more evidence that the subjects in this class rated themselves as more masculine than members of the general population would.

Figure 2. Mean BSRI Ratio for Males and Females with Error

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>50.43103125</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>52.6819375</td>
<td></td>
</tr>
</tbody>
</table>
Table 13. Descriptives for BSRI Ratio

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
</table>

**Analysis and Linear Regressions**

Linear regressions were performed on various factors to determine correlations. To perform a linear regression, we first look at a scatter plot to determine if there’s a linear relationship between the variables. If a linear relationship is observed, a least-squares linear regression is performed, creating a best-fit line with the general formula $Y = a + bX$. In this formula, $Y$ is the dependent variable, $X$ is the independent variable, $a$ is the $Y$-intercept and $b$ is the slope of the line.

Coefficient of determination ($R^2$) was also ascertained for each of the correlations found. $R^2$ is a value between zero and one that indicates how well data points fit a linear regression. $R^2$ indicates the proportion of the independent variable which can be explained by the dependent variable.

Seven significant predictors of posttest were identified. Listed in order of decreasing significance they are as follows: pretest score, emphasis on conceptual learning, preference for male friends, number of siblings, math score, parents’ combined education level, and motivation in physics.
Pretest Score as a Predictor of Posttest Score

Overall, pretest score can account for 26.8% of variation in posttest score. These results are shown in Table 14.

Table 14. Model Summary for Pretest as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.517(^a)</td>
<td>.268</td>
<td>11.809696</td>
</tr>
</tbody>
</table>

\(^a\) Predictors: (Constant), Pretest Score

Pretest score was the most significant predictor of posttest score. These results are shown in and Table 15. This is evidence that this particular test was a valid measurement of physics achievement.

Table 15. Linear Regression for Pretest as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>15.576</td>
<td>4.285</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Pretest Score</td>
<td>.727</td>
<td>.134</td>
<td>.517</td>
<td>5.407</td>
</tr>
</tbody>
</table>

\(^a\) Dependent Variable: Posttest Score
Figure 4. Pretest Score as a Predictor of Posttest Score
Conceptual Learning as a Predictor of Posttest Score

Conceptual learning can account for 14.4% of the variation on the posttest score.

These results are shown in Table 16.

Table 16. Model Summary for Conceptual Learning as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.379</td>
<td>.144</td>
<td>.133</td>
<td>12.769201</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Conceptual Learners

Conceptual learning was a significant predictor for posttest. These results are shown in Table 17. Considering that the conceptual learning factor included many variables that implied that the student relied on equations without regard to their meaning and that they weren’t confident in their ability to understand physics in a meaningful way, this is a reasonable outcome. One would expect that students who were confident in their understanding of the subject would perform better on the assessment.

Table 17. Linear Regression for Conceptual Learning as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>37.648</td>
<td>1.410</td>
</tr>
<tr>
<td>Conceptual Learners</td>
<td>5.201</td>
<td>1.419</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score
Algebra Score as a Predictor of Posttest Score

Algebra score can account for 9.7% of variation in posttest score. These results are shown in Table 18.

Table 18. Model Summary for Algebra Score as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.312a</td>
<td>.097</td>
<td>.086</td>
<td>13.111574</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Algebra Score

Algebra score was a significant predictor for posttest. These results are shown in Table 18. This supports prior research on the subject and further validates our study. It does not, however, contribute to an explanation of the gender gap in this study since males and females scored very similarly on the algebra test, and sex was not a significant predictor of algebra score.

Table 19. Linear Regression for Algebra Score as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>24.151</td>
<td>4.819</td>
</tr>
<tr>
<td>Math Score</td>
<td>.182</td>
<td>.062</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score
Number of Siblings as a Predictor of Posttest Score

The number of siblings that the subjects had was a significant predictor for posttest score. These results are shown in Table 20. This supports previous research on the subject and also further validates our study.

Table 20. Linear Regression for Number of Siblings as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>43.212</td>
<td>2.380</td>
<td>18.157</td>
<td>.000</td>
</tr>
<tr>
<td>Number of siblings</td>
<td>-2.944</td>
<td>.999</td>
<td>-.313</td>
<td>-2.945</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score

Number of siblings can account for 9.8% of variation in posttest score. These results are shown in Table 21.

Table 21. Model Summary for Number of Siblings as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.313a</td>
<td>.098</td>
<td>13.107648</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Number of siblings
Combined Parents’ Education Level as a Predictor of Posttest Score

Combined parents’ education level accounted for 6.8% of variation in posttest score. These results are shown in Table 22.

Table 22. Model Summary for Parents Combined Education as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.282a</td>
<td>.080</td>
<td>.068</td>
<td>13.238747</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Parents combined education

The combined parents education level in this study was a significant predictor for posttest. These results are shown in Table 23.

Table 23. Linear Regression for Parents Combined Education as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>32.360</td>
<td>2.485</td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Parents combined education</td>
<td>1.869</td>
<td>.710</td>
<td>.282</td>
<td>2.632</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score

This supports prior research on the subject and also further validates our study. It was also found that parents combined education level was a significant predictor of desire for physics knowledge in males. These results are shown in Table 24. This was not
significant in females. The reason for this is unclear. According to a thorough literature review, this is a new result and requires further study.

Table 24. Model Summary for Parents Combined Education as a Predictor of Motivation in Physics in Males

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Constant)</td>
<td>-.447</td>
<td>.256</td>
<td>-1.743</td>
<td>.094</td>
</tr>
<tr>
<td>Parents combined education</td>
<td>.230</td>
<td>.073</td>
<td>.533</td>
<td>3.147</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Motivated in Physics
b. Selecting only cases for which Sex = Male
Motivation in Physics as a Predictor of Posttest Score

Motivation to understand physics was, not surprisingly, a significant predictor of posttest score. These results are shown in Table 25.

Table 25. Model Summary for Motivation in Physics as a Predictor of Posttest

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.280a</td>
<td>.078</td>
<td>.067</td>
<td>13.247382</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Motivated in Physics

Motivation to understand physics accounted for 7.8% of variation in posttest score. These results are shown in Table 26.

Table 26. Model Summary for Motivation in Physics as a Predictor of Posttest Score

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>37.648</td>
<td>1.463</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivated in Physics</td>
<td>3.842</td>
<td>1.472</td>
<td>.280</td>
<td>2.610</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score
Preference for Male Friends as a Predictor for Posttest Score

Preference for Male Friends was a significant predictor of posttest score, as shown in Table 27 and Error! Reference source not found.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>37.648</td>
<td>1.420</td>
<td></td>
<td>26.508</td>
</tr>
<tr>
<td>Prefers male friends</td>
<td>4.973</td>
<td>1.429</td>
<td>.363</td>
<td>3.480</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Posttest Score

Overall, preference for male friends can account for 13.1% of variation in posttest score, as shown in Table 28.

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.363¹</td>
<td>.131</td>
<td>.121</td>
<td>12.860814</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Prefers male friends.
Figure 5. Preference for Male Friends as a Predictor of Posttest Score
A preference for male friends was also shown to correlate significantly with various other predictors of posttest score. For instance, preference for male friends was a significant predictor of algebra score. These results are shown in Table 29.

Table 29. Linear Regression for Preference For Male Friends as a Predictor of Algebra Score

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>74.119</td>
<td>2.548</td>
<td>29.094</td>
<td>.000</td>
</tr>
<tr>
<td>Prefers male friends</td>
<td>5.126</td>
<td>2.563</td>
<td>.218</td>
<td>.049</td>
</tr>
</tbody>
</table>

*a. Dependent Variable: Math Score*

A preference for male friends also was a significant predictor of conceptual learning. These results are shown in Table 30.

Table 30. Linear Regression for Preference For Male Friends as a Predictor of Conceptual Learning

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>2.449E-17</td>
<td>.101</td>
<td>.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Prefers male friends</td>
<td>.409</td>
<td>.102</td>
<td>.409</td>
<td>4.008</td>
</tr>
</tbody>
</table>

*a. Dependent Variable: Conceptual Learners*
Number of Siblings as a Predictor for Masculinity

Number of siblings was found to be a predictor of masculinity. These results are shown in Table 32.

Table 31. Linear Regression for Number of Siblings as a Predictor of Masculinity

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>53.180</td>
<td>1.128</td>
<td>47.148</td>
<td>.000</td>
</tr>
<tr>
<td>Number of siblings</td>
<td>-1.152</td>
<td>.474</td>
<td>-.337</td>
<td>-2.428</td>
</tr>
</tbody>
</table>

a. Dependent Variable: BSRI Percent Masculine

Number of siblings was also found to be a predictor of preference for male friends. These results are shown in Table 32.

Table 32. Linear Regression for Number of Siblings as a Predictor of Preference for Male Friends

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>.383</td>
<td>.175</td>
<td>2.192</td>
<td>.031</td>
</tr>
<tr>
<td>Number of siblings</td>
<td>-.202</td>
<td>.073</td>
<td>-.295</td>
<td>-2.761</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Prefers male friends.
Since preference for male friends was significantly correlated with masculinity as shown in Table 33, it is not surprising that number of siblings was shown to correlate with both. These results are to be expected given the fact that it has been shown that both females and males with more siblings tend to be more feminine (Schagen, et al. 2012).

Table 33. Linear Regression for Masculinity as a Predictor of Preference for Male Friends

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-4.026</td>
<td>1.395</td>
<td>-2.886</td>
<td>.006</td>
</tr>
<tr>
<td>BSRI Ratio</td>
<td>.079</td>
<td>.027</td>
<td>.393</td>
<td>2.900</td>
</tr>
</tbody>
</table>

Masculinity was also shown to correlate with conceptual learning, as shown in Table 34. This supports data from a study done by Andrew Gnefkow which showed that girls were more likely to rely on math than on reasoning when solving physics problems (Gnefkow 2011).

Table 34. Linear Regression for Masculinity as a Predictor of Conceptual Learning

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>-3.193</td>
<td>1.441</td>
<td>-2.216</td>
<td>.032</td>
</tr>
<tr>
<td>BSRI Ratio</td>
<td>.063</td>
<td>.028</td>
<td>.312</td>
<td>2.226</td>
</tr>
</tbody>
</table>

a. Dependent Variable: Conceptual Learners
CHAPTER 4

CONCLUSION

Summary

Females scored 6.2% lower, on average, on the pretest and 7.1% lower on the posttest than males did. This shows that the course being studied may have contributed slightly to the gender gap in physics, but mostly it maintained the gap already in place. Seven significant predictors of posttest score were identified. Listed in order of decreasing significance they are as follows: pretest score, emphasis on conceptual learning, preference for male friends, number of siblings, motivation in physics, algebra score, and parents’ combined education level. The results of this study are summarized graphically in Figure 4. The fact that the pretest was the most significant predictor for posttest indicates that this particular test was a valid measurement of physics achievement.
Figure 3. Significant Correlates

- Gender Identity
- Conceptual Learning
- Posttest Score
- Algebra Score
- Male Friend Preference
- Motivation in Physics
- Number of Siblings

Correlation coefficients:
- Gender Identity: .393, .312, -.337
- Conceptual Learning: .409, .379, -.209, -.313
- Posttest Score: .363, .312, -.295, -.313, -.182
Aside from pretest, emphasis on conceptual learning was found to be the most significant predictor of posttest performance, which is a reasonable outcome considering that the conceptual learning factor included many variables that implied that the student relied on equations without regard to their meaning and that they weren’t confident in their ability to understand physics in a meaningful way. One would expect that students who were confident in their understanding of the subject would perform better on the assessment. This is an area where we see a connection to the sex gap in physics, as it was found that males scored significantly higher on the conceptual learning factor than females did. This is not surprising when we consider that boys are more likely to be encouraged to explore and wander farther (Dembo 1994), to keep trying when faced with a difficult problem (Rothman 1991), and to do hands on work in a laboratory setting (Hanson 1992). However, conceptual learning correlated not only with sex, but also with gender, as it also was found to be predicted by a preference for male friends as well as masculinity. This could be evidence of a leak in the metaphorical pipeline. It is possible that the more feminine portion of the student population may be missing from this sample because they have self-selected themselves out of physics by this point. Therefore, the subjects might have more masculine characteristics than the general public.

Preference for male friends was also found as a predictor of posttest score. On first instinct, one might dismiss this as simply another test showing that males perform better than females in physics since one would assume that females and males are both more likely to prefer friends of their own sex. However, preference for male friends was still found to be a predictor of posttest score when looking at the sexes separately. Both
males and females with a preference for male friends performed significantly better on the posttest than those with a preference for female friends. This indicates that, in general, people that feel more comfortable in a male dominated climate perform better in physics. Considering the relationship between a preference for male friends, conceptual learning, and posttest score, this is probably related to a lifetime of activity and experience.

Algebra score was a predictor for posttest, which supports previous research on the subject, but at first glance doesn’t seem to explain the gender gap because a significant difference in math score was not shown between males and females. However, these statistics could be skewed by the fact that the students in this study had already chosen to take a physics course and therefore probably had a substantial math background. When we look at how algebra score is related to preference for male friends though, a significant correlation appears. Although both sexes had similar average scores on the algebra test, both males and females who preferred male friends performed better on the algebra test.

Number of siblings was found to be another predictor of posttest score and was also shown to be negatively correlated with conceptual learning, masculinity, and preference for male friends. Although several studies have shown that individuals with the fewest siblings are the most successful across numerous measures of educational attainment, intellectual achievement, and cognitive skills (Hauser and Kuo 1998; Cicirelli 1978; Duncan 1967), and various studies have shown that people with more siblings tend to be more feminine (Blanchard 1997; Schagen, et al. 2012; Katz and Rank 1981), little
research has been done on the specific implications of this in science education. Parents’ education level was also found to predict posttest, but this doesn’t seem to be implicated in the gender gap, as no significant difference was found between males and females in this area.

**Interventions**

There are two different approaches to attempting to close the gender gap in physics. Put simply, the first of these approaches is to change girls, and the second is to change physics. Since we have already discussed the fact that women have something unique and important to bring to physics, changing them so that they’re more like men would not be desirable. Instead, we have to find some common ground between the two approaches. We need to encourage girls to embrace their scientific side while working to change the culture of science so that it is more accessible to girls.

Three national-level proposals for science education reform have been created in response to several studies showing that the United States is ill prepared to compete effectively in the global economy due to a lack of scientific literacy in the general populace (Eisenhart, Finkel and Marion 1996). The American Association for the Advancement of Science's Project 2061 was created in 1985 when Haley’s comet was last seen in our sky, and was named for the year that the comet would return. The project’s name was chosen as a reminder that the envisioned reform would be long term and substantial. The National Science Teachers Association’s Project on Scope, Sequence, and Coordination of Secondary School Science was started in 1988 with the intention of increasing scientific literacy by changing the way that science education is
organized and reforming the way that science is taught. The National Research Council’s National Science Education Standards were developed with the goal of a scientifically literate citizenry. In the interest of spreading scientific literacy to all members of the population, all three of these programs have been working to remedy the disproportionately low percentages of women and minorities in many science fields. They have developed many strategies and programs with this goal in mind, and continue to do so.

The first, and perhaps most important, thing that we can do to reduce the gender gap in physics, as well as in other STEM fields, is to rework the K-12 curriculum. We need to encourage girls in science from a young age by encouraging them to participate in science fairs, to handle lab equipment, and to participate in hands-on inquiry activities. We also need to put a greater emphasis on collaboration and group work in science. Since we know that a lack of adequate role models is another reason for the gender gap in STEM fields (Lent 1994), schools could also invite female scientists and engineers to speak to girls.

In the home, girls can be encouraged to build their scientific inquiry through playing with toys designed with that intent. There are always the basics such as microscopes, chemistry kits, and rock polishers, but more and more toys are being developed with the particular goal of inspiring girls’ confidence and interest in STEM. For instance, Alice Brooks and Bettina Chen, both of whom have master’s degrees in engineering from Stanford, started a company that sells a product called Roominate, a build-your-own wired dollhouse. The idea is that girls love to design and personalize, so
they enjoy this toy without even realizing how much they’re learning about construction and circuitry. (Brooks and Chen 2013) Another example is GoldieBlox, a brand founded by Debra Sterling, another Stanford engineer. GoldieBlox is a book series coupled with a building set. The series follows a girl named Goldie who is a kid inventor and engineer. Through her adventures she is required to build simple machines to help solve her problems, and girls can use their GoldieBlox kit to build along with her. For instance, in her debut story, “Goldie and the Spinning Machine” girls help Goldie build a belt drive out of pegs and ribbon to help her dog chase his tail. (Sterling 2013) Bigger companies are getting in on the trend as well. For instance, in 2012, Mattel Inc.’s Barbie partnered with a company called MegaBlox and began selling a line called Barbie Build n’ Style, which girls can use to build anything from a mansion to an ice-cream cart. Also, Lego, which has classically been thought of by most as a toy for boys, launched a new line called Lego Friends which is designed especially for girls. The line features five girls who are friends and for whom girls can build anything from houses to cafes. (Kapp 2013) Toys such as these encourage spatial skills, which are incredibly important for confidence in STEM and in physics in particular.

**Recommendations for Physics Departments in Higher-Education**

A study done at the University of Colorado showed that almost half of students reported a decreased interest in physics over the course of their first semester of introductory physics, and a third of those students stated their personal failure was the reason for their decreased interest (Kost, Pollock and Finkelstein 2009). The way that students feel about their introductory physics courses can definitely impact whether or
not they will continue in the field. For this reason, we need to ensure that these classes are as accessible as possible to all students, and particularly to females. We should also concentrate on encouraging students and providing them with a positive experience rather than intimidating them and making them feel inadequate.

One step that we can take to encourage women to succeed in university physics is to provide introductory courses specialized to the needs and wants of female students. One concern many women have about taking physics classes is whether they will be too far behind to succeed (Kost, Pollock and Finkelstein 2007), so an introductory course could make them feel more comfortable. These introductory courses should provide students with scaffolding that will be necessary for general first year physics courses, but that the professor for those courses might not think to, or have time to, go over. These introductory courses would be especially necessary for students who hadn’t taken physics in high school and could include such skills as unit conversion, scientific notation, essential geometry and trigonometry, and the basics of the use of and notation for vectors. These wouldn’t necessarily need to be offered as full courses, but could instead be offered online or as short workshops given before the beginning of the semester.

Many studies (including this one) have shown that women work better in groups (Sax 2006). Hence, one way to reduce the gender gap in physics would theoretically be to make classes more collaborative, therefore encouraging feminine characteristics. One study showed that as attention to conceptual understanding, interactivity and collaboration are increased in first year undergraduate physics classrooms, the gender gap
decreases, and in fact, in fully interactive classes the gender gap is eliminated entirely (Pollock, Finkelstein and Kost 2007).

While we have discussed the fact that the biggest leak in the pipeline occurs before girls enter undergraduate school (Ivie and Ray 2005), we must remember that the teachers who teach high school physics are required to take physics themselves at the university level. Since we know that people have a tendency to teach the way that they were taught (Britzman 1991), we must be sure to model effective instruction in undergraduate physics in hopes that those practices will be carried on by the pre-service teachers in those classes.

Once again bearing in mind that people have the tendency to teach how they were taught, we must also consider the fact that college physics professors very rarely are provided with any formal instruction on how to teach. They can therefore be expected to teach physics very similarly to how they were taught it themselves, without consideration for the interventions that have been discovered through years of research. For this reason, it is suggested that university physics departments provide professional development for their professors and graduate teaching assistants. There are many ways that this sort of professional development could be provided, but one possible method is outlined below.

The professional development will take place during the week before the beginning of the fall semester every year. All professors and G.T.A.s will be required to attend the first session, but only new faculty or faculty who have not attended a session in the last five years will be required to attend future professional development days. A
session will take place between 8:00 A.M. and 5:00 P.M. with an hour long break for lunch. It will be broken down into four two-hour sections with short breaks in between.

The first session will cover basics of classroom management. For instance, the leader of the section will talk about the importance of proximity, subtle gestures, and symbols such as eye contact and “the pregnant pause” in discipline. These techniques can correct disruptive or inappropriate behavior without unnecessary interference with the lesson or the embarrassment of the student. This is particularly important for female students who have a much harder time learning when they experience feelings of confrontation (Evans, et al. 2001). This section would also cover the portrayal of emotional objectivity, or the conscious attempt by teachers to show no favoritism or discrimination in the classroom. For instance, professors will be encouraged to keep track of who they call on in class and make sure that they give every student a chance to answer questions, particularly women and minorities.

The second session will focus on ways for professors to present themselves as accessible to students as opposed to intimidating. One common mistake of physics professors and G.T.A.s is speaking in terms that are above the level of the students in their class. This is an easy mistake to make since we are all more comfortable speaking at our own level, but it can leave students feeling discouraged and left behind. Students are often hesitant to bring attention to this because they are worried they will be seen as ignorant or because they assume that they should be familiar with those terms and they are just behind on the material. Therefore professors should be sure to let students know that they will never be judged for asking a question and should leave plenty of time for
questioning and individual help. Physics professors also have a tendency to provide verbal feedback to students’ answers in class and to correct homework and tests in a way that can be interpreted as aggressive and demeaning as opposed to supportive and encouraging. This is a particular problem for females since, unlike males, they have been shown to become extremely handicapped in their ability to learn after experiencing stress (Shors 2002). Also, as discussed earlier, if a student feels they have performed poorly in an introductory physics class, they are much less likely to continue in the field (Pollock, Finkelstein and Kost 2007).

The third session will go over ways to encourage students and make them feel that they are a valuable addition to the class. The leader would discuss methods of encouragement such as short verbal affirmations, nonverbal signals such as smiling and giving a thumbs-up. Another classic method of encouragement is “catching students being good”. This means recognizing and acknowledging positive student behavior and correct work. Even if a student gets 90% of the problems wrong on an exam, it is still helpful to draw a smiley face or write a positive comment next to the 10% that the student answered correctly. One more thing that professors can do to provide encouragement is allow wait time and give hints and encouragement when a student is struggling to answer a question in class instead of answering the question for them or asking another student to answer it.

The fourth and last session will pay particular attention to methods for addressing the needs of minorities and women. For instance, methods for addressing multiple intelligences would be suggested. These would include discussion time, lecture time,
reading time and time for demonstrations and labs. Competition and hierarchy should be avoided since females prefer equality (Benenson and Schinazi 2004). Collaboration and group work should play a much more prominent role in physics classes since it has been shown that not only do girls prefer to work in groups, but women learn more in interactive environments and the gender gap can even be eliminated when fully interactive engagement techniques are used (Kost, Pollock and Finkelstein 2007). Professors should be sure to draw attention to female role models in physics whenever possible. This is something that can be worked on in the department as a whole. For instance, the department could be sure to invite as many female and minority colloquium speakers as possible. For instance, departments should continue to actively seek female speakers for colloquia and other seminars.

**Future Works**

First of all, it would be enlightening to implement the interventions discussed in the previous section and then perform a similar study to this one to determine the effects. Since the goal of the interventions would be an increase in the number of women deciding to study physics after taking an introductory physics course, the number of females in the department should also be tracked throughout their implementation. Women in the department could also be regularly surveyed to determine how their feelings about physics and about the department had been affected by the changes.

This study was limited by the questions asked on the surveys. For instance, it would be interesting to look deeper into the correlation between number of siblings, gender identity, preference for male friends, conceptual learning, and physics
achievement. Does it matter what the birth order of the student is compared to his or her siblings? Does it matter how far apart siblings are in age? Could we find or develop a better test for gender identity? Also, there were only two questions each on the survey about parent closeness and teacher preference. What would we find if we had a more thorough understanding of these factors?

The test that we used to measure physics achievement was a conceptual physics test, but what if we also looked at how students did on a formal algebra based physics test? Would we still see the same correlations that we observed in this study? Or would we see an increased correlation with algebra score and a decreased correlation with conceptual learning? Another way to find evidence for this would be to look at the way in which the test is presented. The conceptual test given in this survey was presented without work space. Looking at the type of problems and the lack of space to work the problems out with equations, formal learners might not have considered the possibility of working problems out formally. Would we see a difference in performance if the test was presented with work space provided?

It would also be enlightening to perform more of a qualitative study where we ask students about their experiences with physics and dig a little deeper into the relationship between the correlates found in this study. For instance, if a female student is struggling in physics we could ask her about her siblings and how they affect her life and her expectations, how her relationships with males affect her interest in something as male dominated as physics, and how she feels about using equations and conceptual learning.
People who have succeeded in physics and entered the field should also be investigated. Do those people have a relatively low number of siblings and a preference for male friends and colleagues? Do they tend to rely on equations or do they feel confident in their conceptual understanding of physics?

Lastly, this study asserts that traditional lecture style physics courses do not correct the gender gap and therefore physics courses should focus more on group work and conceptual understanding. In order for this assertion to be shown to be true, this study should be repeated in a class where such interventions have been performed in order to evaluate their effectiveness.
APPENDIX: ITEMS INCLUDED ON SURVEYS

Selected Questions from Paul Hewitt’s Sixty Questions
That Every Physics Student Should Know

Choose the best answer to the following:

1. In the absence of air resistance, a ball of mass $m$ is tossed upward to reach a height of 20 m. At the 10-m position, half way up, the net force on the ball is
   A. $2mg$.
   B. $mg$.
   C. $mg/2$.
   D. $mg/4$.

2. When you drop a ball it accelerates downward at 9.8 m/s$^2$. If you instead throw it downward, then its acceleration immediately after leaving your hand, assuming no air resistance, is
   A. 9.8 m/s$^2$.
   B. more than 9.8 m/s$^2$.
   C. less than 9.8 m/s$^2$.
   D. Cannot say, unless the speed of throw is given.

3. A heavy rock and a light rock in free fall (zero air resistance) have the same acceleration. The reason the heavy rock doesn’t have a greater acceleration is that the
   A. force due to gravity is the same on each.
   B. air resistance is always zero in free fall.
   C. inertia of both rocks is the same.
   D. ratio of force to mass is the same.
   E. None of these.

4. A cannonball is fired horizontally at 10 m/s from a cliff. Its speed one second after being fired is about
   A. 10 m/s.
   B. 14 m/s.
   C. 16 m/s.
   D. 20 m/s.
5. Relative to the ground, an airplane gains speed when it encounters wind from behind, and loses speed when it encounters wind head on. When it encounters wind at a right angle to the direction it is pointing, its speed relative to the ground below
   A. increases.
   B. decreases.
   C. is the same as if there were no wind.
   D. Need more information.

6. A karate chop delivers a force of 3000 N to a board that breaks. The force that the board exerts on the hand during this event is
   A. less than 3000 N.
   B. 3000 N.
   C. greater than 3000 N.
   D. Need more information.

7. A math book and a physics book are tied together with a length of string. With the string taut, one book is pushed off the edge of a table. As it falls, the other book is dragged horizontally across the table surface. With no friction, acceleration of the books is
   A. zero.
   B. g/2.
   C. g.
   D. a value between zero and g.
   E. a value that could be greater than g.

8. When an increase in speed doubles the momentum of a moving body, its kinetic energy
   A. increases, but less than doubles.
   B. doubles.
   C. more than doubles.
   D. depends on factors not stated.

9. When an increase in speed doubles the kinetic energy of a moving body, its momentum
   A. increases, but less than doubles.
   B. doubles.
   C. more than doubles.
   D. depends on factors not stated.

10. Big brother and little sister can balance on a seesaw because of balanced
    A. forces.
    B. torques.
    C. energies.
    D. All of these.
11. When a spinning system contracts in the absence of an external torque, its rotational speed increases and its angular momentum
A. decreases.
B. increases.
C. remains unchanged.
D. may increase or decrease.

12. Consider a ball rolling down an inclined plane. The normal force on the ball (the force perpendicular to the plane).
A. is \( mg \).
B. is greater than \( mg \), always.
C. may be greater or less than \( mg \).
D. is less than \( mg \), always.

13. Consider a ball rolling in a horizontal circular path on the inside surface of a cone. The normal force on the ball
A. is \( mg \).
B. is greater than \( mg \), always.
C. may be greater or less than \( mg \).
D. is less than \( mg \), always.

14. When a ball at rest hangs by a single vertical string, tension in the string is \( mg \). If the ball is made to move in a horizontal circle so that the string describes a cone, string tension
A. is \( mg \).
B. is greater than \( mg \), always.
C. is less than \( mg \), always.
D. may be greater or less than \( mg \) depending on the speed of the ball.

15. Imagine you're standing on the surface of a shrinking planet. If it shrinks to one-tenth its original diameter with no change in mass, on the shrunken surface you'd weigh
A. \( 1/100 \) as much.
B. 10 times as much.
C. 100 times as much.
D. 1000 times as much.
E. None of these.

16. The fact that the Moon always shows its same face to Earth is evidence that the Moon rotates about its axis about once per
A. day.
B. month.
C. year.
D. None of these, for the moon does not rotate about an axis.
17. The Moon is most responsible for Earth’s tides. Which pulls more strongly on the Earth and its oceans?
   A. Moon.
   B. Sun.
   C. Both about equally.

18. A spacecraft on its way from Earth to the Moon is pulled equally by Earth and Moon when it is
   A. closer to the Earth’s surface.
   B. closer to the Moon’s surface.
   C. half way from Earth to Moon.
   D. At no point, since Earth always pulls more strongly.

19. Earth satellites such as the Space Shuttle orbit at altitudes that are above the Earth’s
   A. atmosphere.
   B. gravitational field.
   C. Both of these.

20. The mass of a classical atom comes mostly from its _____; and its volume from its _____.
   A. nucleons; nucleons.
   B. electrons; electrons.
   C. electrons; nucleons.
   D. nucleons; electrons.

21. Consider a block of wood floating on water. If you push down on the top of the block until it’s completely submerged, the buoyant force on it
   A. increases.
   B. decreases.
   C. remains the same.
   D. depends on how far beneath the water surface it is pushed.

22. An inflated balloon with a heavy rock tied to it submerges in water. As the balloon sinks deeper and deeper, the buoyant force acting on it
   A. increases.
   B. decreases.
   C. remains largely unchanged.
   D. Need more information.

23. The principal source of the Earth’s internal energy is
   A. tidal friction.
   B. gravitational pressure.
   C. radioactivity.
   D. geothermal heat.
24. The surface of Planet Earth loses energy to outer space due mostly to  
A. conduction.  
B. convection.  
C. radiation.  
D. radioactivity.  

25. The "greenhouse gases" that contribute to global warming absorb  
A. more visible radiation than infrared.  
B. more infrared radiation than visible.  
C. visible and infrared about equally.  
D. very little radiation of any kind.  

26. In a mixture of hydrogen, oxygen, and nitrogen gases at a given temperature, the molecules having the greatest average speed are those of  
A. hydrogen.  
B. oxygen.  
C. nitrogen.  
D. But all have the same speed on average.
Selected Questions from Mechanic Baseline Test

Choose the best answer to the following:

The graph represents the motion of an object moving in one direction.

![Graph showing velocity vs. time]

27. What is the object’s average acceleration between t = 0 and t = 6.0 s?
   a. 3.0 m/s²  b. 1.5 m/s²  c. 0.83 m/s²  d. 0.67 m/s²  e. None of the above

28. How far did the object travel between t = 0 and t = 6.0 s?
   a. 20 m  b. 8.0 m  c. 6.0 m  d. 1.5 m  e. None of the above

29. What was the average speed of the object for the first 6.0 s?
   a. 3.3 m/s  b. 3.0 m/s  c. 1.8 m/s  d. 1.3 m/s  e. None of the above
The diagram depicts two pucks on a frictionless table. Puck II is four times as massive as puck I. Starting from rest, the pucks are pushed across the table by two equal forces.

30. Which puck will have the greater kinetic energy upon reaching the finish line?
   a. I
   b. II
   c. They will both have the same amount.
   e. Too little information to answer.

31. Which puck will reach the finish line first?
   a. I
   b. II
   c. They will both reach at the same time.
   e. Too little information to answer.

32. Which puck will have the greater momentum upon reaching the finish line?
   a. I
   b. II
c. They will both have the same momentum.
e. Too little information to answer.

Use the diagram shown to answer the following questions.

A person pulls a block of mass m across a rough horizontal surface at a constant speed by applying a force F. The arrows in the diagram correctly indicate the direction, but not necessarily the magnitudes of the various forces on the block.

33. Which of the following relations among the force magnitudes W (the weight of the block), k (the kinetic frictional force), N (the normal force), and F (the pulling force) must be true?

a. \( F = k \) and \( N = W \)
b. \( F = k \) and \( N > W \)
c. \( F > k \) and \( N < W \)
d. \( F > k \) and \( N = W \)
e. None of the above choices

34. What is the net force experienced by the block is expressed as:

a. \( F_{\text{net}} = N - W + F - k \)
b. \( F_{\text{net}} = m ( F - k) \)
c. \( F_{\text{net}} = 0 \)
d. \( F_{\text{net}} = m F \sin \theta \)
e. None of the above choices
35. In the direction of motion, the sum of the forces are expressed as:

a. \(F \cos \theta + k\)
b. \(F \sin \theta - k\)
c. \(F \cos \theta - k - W + N\)
d. \(F \cos \theta - k\)
e. None of the above choices
Algebra Assessment

Choose the best answer for each of the following questions.

36. Solve for x: \(3x - 2 = 13\)
   A. \(x = 4\)
   B. \(x = 5\)
   C. \(x = 11/3\)
   D. \(x = -6\)
   E. None of the above

37. Solve for x: \(-(2x + 16) = 4\)
   A. \(x = -10\)
   B. \(x = 6\)
   C. \(x = -6\)
   D. \(x = 5\)
   E. None of the above

38. There are 27 boys in a class. This is three more than three times the number of girls. How many girls are there in the class?
   A. 10 girls
   B. 4 girls
   C. 9 girls
   D. 8 girls
   E. None of the above

39. Solve for x: \(2x^2 + 8 = 40\)
   A. \(x = 4\)
   B. \(x = \sqrt{14}\)
   C. \(x = \sqrt{30}\)
   D. \(x = 16\)
   E. None of the above

40. Solve for x: \(x^2 + 2x + 1 = 0\)

For \(ax^2 + bx + c = 0\)
   \(x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\)
   A. \(x = 1\)
   B. \(x = -1\)
   C. \(-1 \pm \sqrt{2}\)
   D. \(-1\) and \(1\)
   E. None of the above
41. Suppose that one leg of a right triangle is one inch longer than the other leg. If the hypotenuse of the triangle is five inches, what is the length of the shorter leg? For a right triangle with legs of length a and b, and a hypotenuse of length c, we know that $a^2 + b^2 = c^2$

A. 5 in.
B. 4 in.
C. 3 in.
D. $\sqrt{7}$ in.
E. None of the above

42. Given the following sets of equations, solve for x and y:

\[
\begin{align*}
    x - y &= 8 \\
    3y - x &= 18
\end{align*}
\]

A. x = 21, y = 13
B. $x = \frac{3}{2}, y = \frac{13}{2}$
C. x = 3, y = -5
D. x = 9, y = 3
E. None of the above

43. Given the following set of equations, solve for x and y:

\[
\begin{align*}
    -3x + y &= 9 \\
    3y - 2x &= 6
\end{align*}
\]

A. x = 3, y = 4
B. $x = \frac{21}{11}, y = \frac{162}{11}$
C. x = 1, y = 12
D. x = -3, y = 0
E. None of the above

44. Molly is ten years older than Dan. Next year, she will be twice as old as Dan. How old are Molly and Dan currently?

A. Molly = 19, Dan = 9
B. Molly = 15, Dan = 5
C. Molly = 26, Dan = 13
D. Molly = 5, Dan = 15
E. None of the above
Habits Survey

For the following questions use the following scale when applicable: A-strongly agree, B-agree, C-neutral, D-disagree, and E-strongly disagree.

45. When completing my homework, I work in a small group.

46. Throughout the semester, I complete my homework at least a day before it is due.

47. Throughout the semester, I use study groups to gain a better understanding of the material being taught in class.

48. Throughout the semester, I use study groups to prepare for exams.

49. Throughout the semester, I use study groups to complete my lab reports.

50. I attend class on a regular basis.

51. I read sections of the text book when I find that I do not understand a particular concept.

52. I need to have an understanding of physics to achieve my career goals.
Selected Questions from Maryland Physics Expectations Survey

For the following questions use the following scale: A- strongly agree, B-agree, C-neutral, D-disagree, and E-strongly disagree.

36. All I need to do to understand most of the basic ideas in this course is just read the text, work most of the problems, and/or pay close attention in class.

37. All I learn from a derivation or proof of a formula is that the formula obtained is valid and that it is OK to use it in problems.

38. I go over my class notes carefully to prepare for tests in this course.

39. "Problem solving" in physics basically means matching problems with facts or equations and then substituting values to get a number.

40. Learning physics made me change some of my ideas about how the physical world works.

41. I spend a lot of time figuring out and understanding at least some of the derivations or proofs given either in class or in the text.

42. I read the text in detail and work through many of the examples given there.

43. In this course, I do not expect to understand equations in an intuitive sense; they must just be taken as givens.

44. The best way for me to learn physics is by solving many problems rather than by carefully analyzing a few in detail.

45. Physical laws have little relation to what I experience in the real world.

46. A good understanding of physics is necessary for me to achieve my career goals. A good grade in this course is not enough.

47. Knowledge in physics consists of many pieces of information each of which applies primarily to a specific situation.

48. My grade in this course is primarily determined by how familiar I am with the material. Insight or creativity has little to do with it.

49. Learning physics is a matter of acquiring knowledge that is specifically located in the laws, principles, and equations given in class and/or in the textbook.
50. In doing a physics problem, if my calculation gives a result that differs significantly from what I expect, I'd have to trust the calculation.

51. The derivations or proofs of equations in class or in the text has little to do with solving problems or with the skills I need to succeed in this course.

52. Only very few specially qualified people are capable of really understanding physics.

53. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed.

54. The most crucial thing in solving a physics problem is finding the right equation to use.

55. If I don't remember a particular equation needed for a problem in an exam there's nothing much I can do (legally!) to come up with it.

56. If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer that seemed most reasonable. (Assume the answer is not in the back of the book.)

57. Physics is related to the real world and it sometimes helps to think about the connection, but it is rarely essential for what I have to do in this course.

58. The main skill I get out of this course is learning how to solve physics problems.

59. The results of an exam don't give me any useful guidance to improve my understanding of the course material. All the learning associated with an exam is in the studying I do before it takes place.
Social Network and Attitudes Survey

60. My closest friends are…
   a) All female
   b) Mostly female
   c) About half and half
   d) Mostly male
   e) All male

61. My current best friend is…
   a) Female
   b) Male

62. When I participate in a social event, the people I go with are usually…
   a) All female
   b) Mostly female
   c) About half and half
   d) Mostly male
   e) All male

63. When I am required to participate in a group activity for school, I usually choose group members who are…
   a) All female
   b) Mostly female
   c) About half and half
   d) Mostly male
   e) All male

64. How many female siblings do you have?
   a) Zero
   b) One
   c) Two
   d) Three
   e) More than three

65. How many male siblings do you have?
   a) Zero
   b) One
   c) Two
   d) Three
   e) More than three

66. When I have a problem and wish to seek parental advice, I…
   a) Always go to my female guardian only
b) Usually go to my female guardian  
c) Go to both guardians equally  
d) Usually go to my male guardian  
e) Always go to my male guardian only

67. Has one guardian been more active in your life than the other?  
a) Only my female guardian has been active  
b) My female guardian has been more active than my male guardian  
c) Both of my guardians have been equally active  
d) My male guardian has been more active than my female guardian  
e) Only my male guardian has been active

68. Think about your favorite teacher or professor. What is their gender?  
a) Female  
b) Male

69. Overall, I feel that I relate best to  
a) Female teachers  
b) Male teachers  
c) I haven’t noticed a difference

70. Think about your greatest role model. What is their gender?  
a) Female  
b) Male

71. When completing an assignment, I would rather work  
a) Alone  
b) In a group

72. Most of the time I like to be  
a) Alone  
b) With just one or two close friends  
c) Surrounded by people

73. In the future I would like a career where I  
a) Work with a group of people all the time  
b) Work sometimes by myself but also collaborate with a group  
c) Work only by myself

74. When I’m in physics lecture I feel that I’m  
a) Learning a lot  
b) Learning a little  
c) Not learning anything
75. When I’m in physics lab I feel that I’m
   a) Learning a lot
   b) Learning a little
   c) Not learning anything

76. When I’m studying physics by myself I feel that I’m
   a) Learning a lot
   b) Learning a little
   c) Not learning anything

77. When I’m studying physics in a study group I feel that I’m
   a) Learning a lot
   b) Learning a little
   c) Not learning anything

78. What is your gender?
   a) Male
   b) Female

79. What is your father’s/male guardian’s educational level?
   a) High school diploma
   b) Trade, vocational, or associates degree
   c) 4-year (bachelor’s) degree
   d) Master’s degree
   e) Ph.D.

80. What is your mother’s/female guardian’s educational level?
   a) High school diploma
   b) Trade, vocational, or associates degree
   c) 4-year (bachelor’s) degree
   d) Master’s degree
   e) Ph.D.
Selections from Bem Sex Role Inventory

For each of the following words, rate how well each describes you using the following scale: Very well B- Somewhat C- neutral D- only a little E- not at all

81. Self-reliant
82. Yielding
83. Defends own beliefs
84. Cheerful
85. Independent
86. Shy
87. Athletic
88. Affectionate
89. Assertive
90. Flatterable
91. Strong personality
92. Loyal
93. Forceful
94. Feminine
95. Analytical
96. Sympathetic
97. Leadership ability
98. Sensitive to other's needs
99. Willing to take risks
100. Understanding
101. Makes decisions easily
102. Compassionate
103. Self-sufficient
104. Eager to soothe hurt feelings
105. Dominant
106. Soft spoken
107. Masculine
108. Warm
109. Willing to take a stand
110. Tender
111. Aggressive
112. Gullible
113. Acts as a leader
114. Childlike
115. Individualistic
116. Does not use harsh language
117. Competitive
118. Loves children
119. Ambitious
120. Gentle
BIBLIOGRAPHY


Rachel Clara Smith was born on September 15th, 1984, in Athens, Georgia. She graduated from Platte County R-III High School in Platte City, Missouri, in 2003. While in high school, Ms. Smith was honored with a Leadership Award in Girl Scouts, a Silver Award in Girl Scouts, the Don Schowalter Award in Chemistry, and the Bank of America Joe Martin Scholarship. She was also chosen as a Bright Flight Scholar and a National Merit Scholar in 2003. She earned a Bachelor of Arts in Physics with departmental honors from University of Missouri-Kansas City in 2009. The following year, she enrolled in the graduate school to pursue her Masters of Science in Physics. Ms. Smith worked as an adjunct physics professor at Rockhurst University before accepting a job at Bishop Ward High School in Kansas City, Kansas where she now teaches physics, chemistry, and astronomy.